

Detailed Chromospheric Activity Nature of KIC 9641031

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Abstract: This study depends on KIC 9641031 eclipsing binary system with a chromospherically active component. There are three type variations, such as geometrical variations due to eclipses, sinusoidal variations due to the rotational modulations and also flares, in the light curves obtained with the data taken from the Kepler Mission Database. Taking into account results obtained from KIC 9641031s observations in the Kepler Mission Database, we present and discuss the details of chromospheric activity. The sinusoidal light variations due to rotational modulation and the flare events were modelled separately. 92 different data subsets separated using the analytic models described in the literature were modelled separately to obtain the cool spot configuration. It is seen that just one component of the system is chromospherically active star. On this component, there are two active regions separated by about 180° longitudinally between the latitudes of $+50^\circ$ and $+100^\circ$, whose locations and forms are rapidly changing in short time intervals. 240 flares were detected and their parameters were computed. Using these parameters, the One Phase Exponential Association (hereafter OPEA) function model was derived, in which the *Plateau* value as a saturation level of the flare-equivalent duration was found to be 1.232 ± 0.069 s for KIC 9641031, and *half-life* parameter was found to be 2291.7 s. The flare frequency N_1 was found to be 0.41632 h^{-1} , while the flare frequency N_2 was found to be 0.00027. Considering these parameters together with the orbital period variations demonstrates that the period variations directly depend on chromospheric activity. Comparing the system with its analogue it is seen that the activity level of KIC 9641031 is remarkably lower than the others. Although activity level of the system is very low, but the sensitivity of the Kepler Satellite is so high that the activity on the component gets into clearly observable range.

Keywords: techniques: photometric methods: data analysis methods: statistical binaries: eclipsing stars: flare stars: individual (KIC 9641031).

1 Introduction

The flare stars as known UV Ceti are generally young dwarf stars from the spectral types G, K and M with emission lines in their spectra, such as dMe, which are just coming to the main sequence. As it was indicated by Mirzoyan (1990) and Pigatto (1990), the population rate of the dwarf stars having flare phenomenon is generally high in both the open clusters and the associations. As it is expected due to the Skumanich's law, the population rate of the stars showing flare activity has a reducing trend, while the age of the cluster gets older (Skumanich 1972; Pettersen 1991; Stauffer 1991; Marcy & Chen 1992).

Strengthening stellar chromospheric activity with increasing the rotation velocity causes much more mass loss from the star. It is known that the stellar mass loss rate of V Ceti type stars is about $10^{-10} M_\odot$ per year due to flare like events, while the solar mass loss rate is about $2 \times 10^{-14} M_\odot$ per year (Gershberg 2005). In the case of UV Ceti type flare stars, this high mass loss rate clarifies how they lose large part of their angular momentum in their main sequence stages (Marcy & Chen 1992). However, the flare activity mechanism resulting high level mass loss has not been completely explained by any theory yet.

Flare events observed on UV Ceti type stars are

generally explained with the classical theory of the solar flare. The highest energy detected from the most powerful flares, known as two-ribbon flares, occurring on the sun is found to be $10^{30} - 10^{31}$ erg (Gershberg 2005; Benz 2008). This level is also observed for RS CVn type active binaries (Haisch et al. 1991). However, in the case of dMe stars, this flare energy level varies from 10^{28} erg to 10^{34} erg (Gershberg 2005). Moreover, some stars of the young clusters such as the Pleiades cluster and the Orion association exhibit some powerful flare events, which energies reach 10^{36} erg (Gershberg & Shakhovskaya 1983). In brief, the stars from different type exhibit some flares with different energy levels. Comparing the sun with a dMe stars, it is seen that there are some remarkable difference between both their flare energy levels and mass loss rate per year. Nevertheless, the flare events occurring on a dMe star are generally tried to explain by the classical theory of solar flare. Therefore, the primary energy source in the flare events is magnetic reconnection processes in the principle (Hudson & Khan 1997; Gershberg 2005). To reach the real situation, examining the flare events occurring on the different type stars, all the differences and similarities should be demonstrated. Then, it should be identified which parameters such as singularity, binarity, mass, age, ect., cause these differences and similarities.

In this study, both flare and stellar cool spot activities observed from a well known eclipsing binary star FL Lyr as a different system apart from classical UV Ceti type flare stars from the spectral type dMe were analysed and modelled. Then, the results were compared with the chromospheric activity behaviour observed on its analogue. The photometric data used in the analyses and models were taken from the Kepler Mission Database (Slawson et al. 2011; Matijević et al. 2012). In the database, FL Lyr is listed with its catalog number as KIC 9641031.

KIC 9641031 has been listed in the Youngest-Field Star Catalog by Guillout et al. (2009), though the system is not young. Brown (2010) given the age of the system between 3.05 Gy and 15.25 Gy. Morgenroth (1935) listed KIC 9641031 as a variable star for the first time in the literature, while Struve et al. (1950) classified the system as a spectroscopic binary with a single line. Macrae (1952) and Miner (1966) observed the system photometrically, especially in the narrow bands.

Although the spectral type of the system is given as $F8V + G8V$ in some catalogue (Eker et al. 2014), the temperatures of the components are given in a large range in the general literature. The temperatures of the primary component are varying from 5724 K (Guillout et al. 2009) to 6412 K (Eker et al. 2014) in the literature. Its temperature is generally accepted to be 6150 K (Brown 2010; Eker et al. 2014). Similarly, the temperatures stated for the secondary component is changing from 5080 K (Guillout et al. 2009) to 5506 K (Popper et al. 1986). It is accepted as 5300 K in general (Brown 2010; Armstrong et al. 2014). The first light curve analysis of the system was made by Jurkevich et al. (1976). In the study, some parameters such as the fractional radii (r), the inclination (i) of the system, the fractional luminosity (L_1) of the primary component were computed. The light curves were analysed together with the radial velocity curve simultaneously by Lacv et al. (1985) for the first time, thus the first approximations were obtained for the masses and radii of the components. The component masses were given as $M_1 = 1.218 M_\odot$ and $M_2 = 0.958 M_\odot$, the radii of the components were given as $R_1 = 1.283 R_\odot$ and $R_2 = 0.963 R_\odot$ by Eker et al. (2014). The semi-major axis (a) of the system was given as $a = 9.17 R_\odot$ and the inclination (i) of the system was given as 86.3° in the same catalogue. According to this view, the components are comparatively far away from each other. Analysing the spectroscopic observations of the system, Cristaldi (1965) asserted existence of some clues for the third body, but Lacy & Evans (1979) did not find any sign for the third body though they obtained the double-lined radial velocity curves of the system. Popper et al. (1986) also obtained the double-lined radial velocity curves of the binary.

As it is seen from the literature, KIC 9641031 is a well studied eclipsing binary for some decades, but the chromospheric activity nature of the system has not been exhaustively studied yet. Botsula (1978) stated that one of the components exhibits magnetic activity. Then, Balona (2015) listed some statistical information about flare activity occurring on the com-

ponents some decades later. However, there is no detailed study about its chromospheric activity nature or any comparison with the other chromospherically active stars about the similarities or differences between them.

In this study based on the Kepler Mission short-cadence light curves, to understand the magnetic activity nature of the system, we analysed and modelled KIC 9641031's light variations due to the stellar cool spots and the flare events occurring on the components as the chromospheric activity indicators. Then, comparing with the results obtained from other stars, our results were discussed for both the cool spots and the flares.

2 Data and Analyses

More than 150.000 targets have been observed in the Kepler Mission, which is aimed to find out exo-planet (Borucki et al. 2010; Koch et al. 2010; Caldwell et al. 2010). The observations in this Mission have the highest quality and sensitivity ever reached in the photometry (Jenkins et al. 2010a,b). In this case, lots of variable targets such as new eclipsing binaries, etc. have been also discovered apart from the exo-planets (Slawson et al. 2011; Matijević et al. 2012). Many targets among these newly discoveries are single or double stars exhibiting chromospheric activity. Some of the double stars are the eclipsing binaries (Balona 2015).

The photometric data of KIC 9641031 were taken from the Kepler Mission Database. All the light curves obtained from these data are together with error bars shown in Figure 1. The error of each point is 0.00008 mag or smaller. Instead of long-cadence light curves, the short-cadence data were used in the analyses and models (Slawson et al. 2011; Matijević et al. 2012). In order to analysis the cool spots, the flare events and the orbital period variation (O-C), the data were arranged as the suitable formats.

2.1 Flare Activity and the OPEA Model

To determine the light variations just due to the flare events, in the first step, all the light variations except the flares were removed from the general light variation. For this purpose, the data of all the primary minima observations between the phases of 0.96-0.04 and all the secondary minima observations between 0.46 and 0.54 in phase were removed from the general light curve data. By the way, all the deviated observations with large error due to the technical problems were also removed from the data sets. And thus, the pre-whitened light curves were obtained.

In the second step, to determine the basic flare parameters such as the first point of the flare beginning, the last point of the flare end and the flare energy, the quiescent levels for each flare should be derived from the residual data of the pre-whitened light curves. However, it was seen that there is a sinusoidal variation due to rotational modulation variation because of the cool spots occurring on the components. Therefore, considering the pre-whitened light curve just out-of-

flare, the light variations seen due to rotational modulation were modelled with the Fourier transform, using the least-squares method. Thus, these synthetic models lead us to define the quiescent levels for each flare at the same time of that flare. Using these synthetic models as the quiescent levels, the parameters of the flares were computed. Two flare light curves taken from the observation data and the quiescent levels derived for these flares are shown in Figures 2 and 3.

Using the synthetic models derived for the quiescent levels, flare rise times (T_r), decay times (T_d), amplitudes of flare maxima, flare equivalent durations (P) were computed, after defining both the flare beginning and the end for each flare. In total, 240 flares were detected from the available data in the Kepler Mission Database. All the computed parameters are listed in Table 1 for these 240 flares. In the table, flare maximum times, equivalent durations, rise times, decay times and amplitudes of flare maxima are listed from the first column to the last, respectively.

The equivalent durations of the flares were computed using Equation (1) taken from Gershberg et al. (1972):

$$P = \int [(I_{flare} - I_0)/I_0] dt \quad (1)$$

where I_0 is the flux of the star in the observing band while in the quiet state. I_0 was computed using the models derived with the Fourier transform. I_{flare} is the intensity observed at the moment of flare. Finally, P is the flare-equivalent duration in the observing band. In this study, the flare energies were not computed to be used in the following analyses due to the reasons described in detail by Dal & Evren (2010, 2011). Before computing the flare-equivalent duration, comparing synthetic models of the quiescent levels with the observations, the times of flare beginning, end and also maximum were defined, and then computing time differences of these points, the flare rise and decay times were calculated.

Examining the relationships of the flare parameters among each other, it is seen that the distributions of flare equivalent durations on the logarithmic scale versus the flare total durations are varying according to a rule. The distributions of flare equivalent durations on the logarithmic scale can not be higher than a specific value for the star, and it is no matter how long the flare total duration is. Using the SPSS V17.0 (Green et al. 1999) and Grahpad Prism V5.02 (Dawson & Trapp 2004) programs, Dal & Evren (2010, 2011) indicated that the best function is the OPEA Model to fit the distributions of flare equivalent durations on the logarithmic scale versus flare total durations. The OPEA function has a *Plateau* term, and this makes it a special function in the analyses. The OPEA function is defined by Equation (2):

$$y = y_0 + (Plateau - y_0) \times (1 - e^{-k \times x}) \quad (2)$$

where the parameter y is the flare equivalent duration on a logarithmic scale, the parameter x is the flare total duration, according to the definition of Dal & Evren (2010), and the parameter y_0 is the flare-equivalent duration in on a logarithmic scale for the least total duration. In other words, the parameter y_0 is the least equivalent duration occurring in a flare for a star. Here is an important point that the parameter y_0 does not depends on only flare mechanism occurring on the star, but also depends on the sensitivity of the optical system used for the observations. The parameter *Plateau* value is upper limit for the flare equivalent duration on the logarithmic scale. Dal & Evren (2011) defined *Plateau* value as a saturation level for a star in the observing band.

Using the least-squares method, the OPEA model was derived for the distributions of flare equivalent durations on the logarithmic scale versus the flare total durations. The derived model is shown in Figure 4 together with the observed flare equivalent durations, while the parameters computed from the model are listed in Table 2. The *span* value listed in the table is difference between *Plateau* and y_0 values. The *half-life* value is half of the first x value, at which the model reaches the *Plateau* value. In other words, it is half of the minimum flare total time, which is enough to the maximum flare energy occurring in the flare mechanism.

It was tested by using three different methods, such as the D'Agostino-Pearson normality test, the Shapiro-Wilk normality test and also the Kolmogorov-Smirnov test, given by D'Agostino & Stephens (1986) to understand whether there are any other functions to fit the distributions of flare equivalent durations on the logarithmic scale versus the flare total durations. In these tests, the probability value called as *p-value* was found to be *p-value* < 0.001. This means that there is no other function to model the distributions of flare equivalent durations (Motulsky 2007; Spanier & Oldham 1987).

KIC 9641031 was observed as long as 576.47474 days from JD 2454964.50251 to JD 2456424.01145 without any remarkable interruptions. In total, significant 240 flares were detected in these observations. The total flare equivalent duration computed from all the flares was found to be 556.81321 s (0.15467 hours). Ishida et al. (1991) described two frequencies for the stellar flare activity. These frequencies are defined as given by Equations (3) and (4):

$$N_1 = \Sigma n_f / \Sigma T_t \quad (3)$$

$$N_2 = \Sigma P / \Sigma T_t \quad (4)$$

where Σn_f is the total flare number detected in the observations, and ΣT_t is the total observing duration, while ΣP is the total equivalent duration obtained from all the flares. In this study, N_1 frequency was found to be 0.41632 h^{-1} , while N_2 frequency was found to be 0.00027.

2.2 Rotational Modulation and Stellar Spot Activity

The light curves of the system indicate the existence of the sinusoidal variations out-of-eclipses. Considering the temperatures of the components, the sinusoidal variations are more likely caused by rotational modulation due to the cool stellar spots. As it is clearly seen from the temperature ranges given in the literature for the components, both the primary and secondary components are potential candidates to exhibit the chromospheric activity. In this study, we assumed that the secondary component is a chromospherically active star. To demonstrate just the sinusoidal variations, both all the minima due to the eclipses of the components and all the flare as seen sudden - rapid increasing in the light were removed from general light curves, thus the remaining light curves were obtained, which is hereafter called as the pre-whitened light curves. Comparing the variations seen in the pre-whitened light curves cycle by cycle according to the orbital period of the system, it was seen that both the phases and levels of maxima and minima are rapidly changing from one cycle to the next. The situation is clearly an indicator for the rapid evolution of the magnetically active regions on the components. In this case, all the pre-whitened light curves can not be modelled as just one data set, because of this, the data set of whole pre-whitened light curves were separated to sub-data sets. In this process, the consecutive cycle data, which have almost the same phase distributions and brightness levels, were arranged as one sub-data set. Thus, all the available data were arranged as 92 sub-data sets and each sub-data set was individually modelled.

To find out the parameters of spot distribution on the stellar surface such as the spot radius, latitude and especially longitude, we modelled the sub-data sets under some assumptions using the SPOTMODEL program (Ribárik 2002, et al. 2003). In this program, the analytic models of Budding (1977) were used to model the sinusoidal variations out-of-eclipses. The program needs two-band observations or spot temperature factor ($kw = [T_{spot}/T_{surface}]^2$) parameter. However, the available data in the Kepler Mission Database contain only monochromatic observations. Therefore, considering the clues of the spot activity for this system stated firstly by Botsula (1978) and also the results obtained from the light curve analyses of its analogue systems (Clausen et al. 2001; Thomas & Weiss 2008), it was assumed that the secondary component exhibits chromospheric activity.

$$L(\theta) = A_0 + \sum_{i=1}^N A_i \cos(i\theta) + \sum_{i=1}^N B_i \sin(i\theta) \quad (5)$$

Considering the coefficients A_i and B_i , the dominant term is $\cos(i\theta)$ for the first ($i = 1$) and second ($i = 2$) orders in the analysis with the Fourier transform described by Equation (5). According to Hall (1990), the $\cos(i\theta)$ term is an indicator for the spotted areas on the surface of a star. In this case, the

previous analyses with the Fourier transform indicate that there are two active regions on the active component. Considering the results of the analogue systems, it was assumed that the spot temperature factors are in the range of $kw = 0.70 - 0.95$ for these cool spots. The initial models by changing the factors from 0.70 to 0.95 reveal that the best solutions are obtained if the spot temperature factor is taken as $kw = 0.75$ for the primary spot (Spot 1), while it is taken as $kw = 0.85$ for the secondary one (Spot 2). Consequently, it was assumed that the spot temperature factors are constant parameters for each sub-data set, and they are taken as $kw = 0.75$ for the first spot and $kw = 0.85$ for the second spot in the each model. Finally, taking the spot temperature factor as a constant, the longitudes (l), latitudes (b) and radii of the spots (g) parameters are taken as the adjustable free parameters in the each model.

Five examples selected from different time intervals among all 92 models derived by SPOTMODEL program are shown in Figure 5. In the figure, both the model fits and the cool spot distributions on 3D surface are seen side by side for these five selected sub-data sets. All the spot parameters derived by SPOTMODEL program are also listed in Table 3. In the table, the average Heliocentric Julian Date of the time interval for each sub-data set (HJD), spot latitudes (b), radii of the spots (g) and spot longitudes (l) are listed from the first column to the last, respectively.

The variations of spot latitude (b), spot radius (g) and spot longitude (l) values versus the time are shown in Figure 6. In this point, it must be noted that if it was assumed that chromospherically active star is not the secondary component, but the primary one, there would be no distinctive changes in the values of spot latitudes (b), radii of the spots (g) and spot longitudes (l). This is because the surface temperatures of the both components are so close to the each other.

2.3 Orbital Period Variation

The minima times were computed with a script depending on the method described by Kwee & van Woerden (1956). Each minimum in the light curves was separately fitted with the high order spline functions. Using these fits, the minima times were computed from the available short cadence detrended data of the system in the Kepler Mission Database (Slawson et al. 2011; Matijević et al. 2012) without any extra correction on these detrended data. For all the minima times, the differences between the observations and the calculations were computed to determine the residuals $(O - C)_I$. Some minima times have very large error, for which the minima light curves were examined. It was seen that there is a flare activity during these minima, then, these minima times were removed from analyses. Finally, 532 minima times were obtained from the observations in the Kepler Mission. Using the regression calculations, a linear correction was applied to the differences, and the $(O - C)_{II}$ residuals were obtained. After the linear correction on $(O - C)_I$, new ephemerides were calculated as following:

$$JD(He.) = 24\,54954.13348(4) + 2^d.1781543(1) \times E. \quad (6)$$

The minima times, epoch, minimum type, $(O-C)_I$ and $(O-C)_{II}$ residuals are listed in Table 4, respectively. The error of each minimum time in the table is 0.00001 day or smaller. The $(O-C)_{II}$ residual variations versus time are shown in Figure 7. As seen from the figure, the $(O-C)_{II}$ residuals exhibit some distorted sinusoidal variations in opposite directions relative to each other. A similar phenomenon has been recently demonstrated for chromospherically active other systems by Tran et al. (2013) and Balaji et al. (2015).

3 Results and Discussion

The analyses of data taken from the Kepler Mission Database (Slawson et al. 2011; Matijević et al. 2012) indicated that KIC 9641031 is a chromospherically active system. However, to reach the certain results about the activity level of the system, it needs to compare the results with its analogues. Considering the temperatures of the components, both components seem to be potential candidates to exhibit the chromospheric activity. However, in this study, we assumed that the secondary component is a chromospherically active star. Using the calibrations given by Tokunaga (2000), we derived $B-V$ color index for the secondary component depending on its temperature generally accepted as 5300 K. According to the calibrations, the $B-V$ color index of a main sequence star with the temperature of 5300 K was found to be $0^m.74$.

KIC 9641031 was observed as long as 576.47474 hours between JD 2454964.50251 and JD 2456424.01145. We found 240 flares from these observations. Apart from other flare parameters, the flare frequencies were also computed. N_1 flare frequency was computed as $0.41632\,h^{-1}$, while N_2 frequency was found to be 0.00027 . Comparing these values with the frequencies found for UV Ceti type flare stars in a wide spectral range, from spectral type dK5e to dM6e, it is clearly seen that the flare energies obtained from KIC 9641031 are remarkably lower than its analogues. In addition, the number of the flare occurring on the star per hour is also remarkably less than its analogues. As it can be seen from the literature, for example, the observed flare number per hour for UV Ceti type single stars was found to be $N_1 = 1.331\,h^{-1}$ in the case of AD Leo, while it was found to be $N_1 = 1.056\,h^{-1}$ for EV Lac. Moreover, N_2 frequency was found to be 0.088 for EQ Peg, while it was found to be $N_2 = 0.086$ for AD Leo (Dal & Evren 2011). According to these values, the flare frequencies of KIC 9641031 are definitely small. However, it is well known from Dal & Evren (2011) that the flare frequency dramatically changes from one season to the next for some stars, such as V1005 Ori, EV Lac, etc. Because of this, there could be some changes in the flare frequency and flare behaviour of KIC 9641031 in the next observing seasons.

On the other hand, this result obtained from the flare frequencies explained why any flare had not been detected from the system by any ground based telescope before the Kepler Mission. Although the flare frequency N_1 indicates that one flare occurs on the star per 2.402 hours, but N_2 frequency demonstrates that the energies of these flare are so small that it is very difficult to detect them with the ground based telescopes. Here it should be noted that, the parameters comparing from the literature were derived from the observation obtained in the standard Johnson U band. However, the observation data used in this study is different band.

The *Plateau* value derived from the OPEA model of the flare equivalent duration distributions on the logarithmic scale versus the flare total durations was found to be 1.232 ± 0.069 for 240 flares of KIC 9641031. According to Dal & Evren (2011), this value is 3.014 for EV Lac ($B-V = 1^m.554$) and 2.935 for EQ Peg ($B-V = 1^m.574$), and also it is 2.637 for V1005 Ori ($B-V = 1^m.307$). As it is seen that the maximum flare energy detected from KIC 9641031 is almost half of the maximum energy level obtained from UV Ceti type single flare stars. Dal & Evren (2011) found that the *Plateau* value is always constant for a star, while it is changing from one star to the next depending on their $B-V$ color indexes. The authors defined the *Plateau* value as the energy saturation level for the flare mechanism occurring on the target star.

The *half-life* value was found to be 2291.7 s. This value is 10 times bigger than those found from UV Ceti type single flare stars. For instance, it was found to be 433.10 s for DO Cep ($B-V = 1^m.604$), and 334.30 s for EQ Peg, while it is 226.30 s for V1005 Ori (Dal & Evren 2011). It means that in the case of the stars such as EQ Peg, V1005 Ori and DO Cep, the flares can reach the maximum energy level at their *Plateau* value, when their total durations reach some 10 minutes, while it needs a few hours for KIC 9641031.

The similar extended durations are seen for the maximum flare rise and total times found from KIC 9641031, whereas these times obtained from UV Ceti type single stars are absolutely shorten than those seen in this system. For example, the maximum flare rise time was found to be 2062 s for V1005 Ori and 1967 s for CR Dra. However, it was found to be 5179 s for KIC 9641031. Similarly, the maximum flare total time was found to be 5236 s for V1005 Ori and 4955 s for CR Dra. In the case of KIC 9641031, it was obtained as 12770.62 s.

As a result, the flare activity level of KIC 9641031 is considerably lower than that seen in the others. However, this is in agreement with the results revealed by Dal & Evren (2011). The authors demonstrated that the parameters derived from the OPEA model get values depending on the $B-V$ color index of the star. Therefore, according to the general trends found by Dal & Evren (2011), the parameters of the KIC 9641031's flares are in agreement with the $B-V$ color index of the secondary component. This situation also indicates that the general trends found by Dal & Evren (2011) are valid around the spectral types of $B-V = 0^m.74$. On the other hand, KIC 9641031

is an eclipsing binary system, so it is a double star. In this case, it is expected that the tidal interactions between the components make the magnetic activity level increase. However, it is not realized in the case of the flare activity patterns.

As seen from the literature, Brown (2010) given the age of the system between 3.05 Gy and 15.25 Gy. According to the relations among the age, rotational period and the magnetic activity level described by Skumanich (1972), the given ages are too high that it should not be expected any high level magnetic activity on the components. Therefore, in the case of KIC 9641031, it is seen that being a component in a binary system does not affect the chromospheric activity as much as it is expected. Because, according to the semi-major axis (a) of the system, the components are too far away from each other to not affect the chromospheric activity.

On the contrary, it seems that KIC 9641031 has very high level spot activity unlike the flare activity. The variation due to rotational modulation is clearly revealed by the Kepler Mission with the highest quality sensitive observations (Jenkins et al. 2010a,b).

The distribution of these spots on the surface was modelled by SPOTMODEL program (Ribárik 2002, et al. 2003). The analyses of the pre-whitened light curves indicate two cool spots on the one component for all 92 sub-data sets. The derived parameters of both spots, such as latitude (b), radius (g) and longitude (l) values, are listed in Table 3, while their variations versus time are shown in Figure 6. The latitudes of the spots are shown in the upper panel of the figure. As it can see, both spots are located between $+50^\circ$ and $+100^\circ$ in the latitude until HJD 24 56300. After this time, one of the spots is rapidly migrating to the latitude range from -50° to -100° , while the other one is stable in that latitude.

In the model, locating of the stellar spots close to one of the poles solves out a problematic behaviour of the flare activity. If the phase distribution of the detected flares is examined, it is seen that there are the flare activity patterns in each phase interval. Although it is normally expected that large number of the flares should be seen in the phase interval, in which the observers directly see the spotted areas on the surface of the star, but this expectation is not working in this system. However, considering both the orbital inclination of $86^\circ.3$ and the spotted area latitudes close to the pole, it is easy to understand that the active regions on the star are always in front of the observers. This situation explains why the flare patterns are seen in each phase interval.

As it is seen from the middle panel of the Figure 6, the longitudes of the spotted areas are overlapped and changed their sides between each other around HJD 24 56300, when the spots changed their locations in the latitude range. There are about 180° longitudinal differences between two spots in the beginning, while the longitudinal differences are decreasing set by set, and finally, two spots changed sides in the longitudinal plane around HJD 24 56300. This is very interesting phenomenon in the astrophysical sense, because the spot with bigger radius is migrating towards the

earlier longitudes, while the second spot with smaller radius is migrating towards the later longitudes. The migrations of both spots get more distinctive according to each other after HJD 24 56300. According to Fekel et al. (2002) and Berdyugina (2005), the behaviour of the spot migration on a star is very important to understand both the rotation of the star and also the dynamo process working its inside.

The variations of the spot radii are seen in the bottom panel of the Figure 6. As seen from the figure, the radii of both spots sometimes increase and sometimes decrease. However, the remarkable point is that the radii of the spots are synchronously varying in opposite directions relative to each other. The radius of one spot is increasing, on the contrary, the radius of the other one is decreasing in the moment. This phenomenon seems to be a recurrent behaviour.

Like the synchronous longitudinal variations of the spots, the synchronous variations of the spot radii demonstrate that the assumption of "both spots are occurring on the same component" in the model is a right approach for this system. If the spots locate on the different components, it should not be expected any apparent synchronous variations like those.

Using the data obtained in the Kepler Mission, we demonstrated some clear variations with very short amplitudes in short time intervals. For example, the amplitude variations of the sinusoidal variation are lower than a few mmag, while it is clearly seen that this amplitude and light curve shapes are changing from one cycle to the next in short time intervals. However, in the case of observations made by the ground based telescopes, the variations of both the amplitude and the shape of the light curve due to the sinusoidal variations caused by rotational modulation can be perceived in a few months at least or generally from one season to the next (Dal et al. 2012).

Considering the studies of Tran et al. (2013) and Balaji et al. (2015), it is expected that the chromospheric activity affects the orbital period of the KIC 9641031. Therefore, all minima times were computed from the short cadence data given in the database. After the linear correction applied to $(O - C)_I$ residuals, $(O - C)_{II}$ residuals were obtained. It is seen that the $(O - C)_{II}$ residuals exhibit a variation as expected. The stellar spot activity occurring on the active component leads the $(O - C)_{II}$ residuals of both the primary and secondary minima to vary synchronously, but in opposite directions, due to the effects presented by Tran et al. (2013) and Balaji et al. (2015). The dominant effect is seen in the $(O - C)_{II}$ residuals of the secondary minima. Moreover, as it is seen in the cases of the spot longitudes and radii, the variation character of the $(O - C)_{II}$ residuals is changed around HJD 24 56300. After this time, there is nearly no separation between $(O - C)_{II}$ residuals of the primary and secondary minima.

In this study, although the secondary component was assumed as chromospherically active component, it is possible that the primary component could be chromospherically active star, too. In this point, considering the parameter variations of the models, it is certain that there are two spotted areas and both of

them are located on the same component.

Consequently, these results in the general respect reveal that KIC 9641031 is an active binary, but not active as much as the eclipsing binaries such as UV Ceti, BY Dra or RS CVn type variables, though one of the components exhibits both the flare and the cool spot activities. Because, both the flare energy level and the flare frequency are saliently lower than those obtained from UV Ceti type flare stars from the spectral type dMe (Dal & Evren 2010, 2011). In addition, although both the minimum location and the shape of sinusoidal light variations due to the rotational modulation out-of-eclipses seem to be rapidly changing, but the amplitude of the variations is not large as much as that observed from other systems (Dal et al. 2012). Nonetheless, KIC 9641031 has one chromospherically active component at least.

In the future, the spectral observations of the system should be done to certainly understand which component is an active star. In addition, the system should be observed photometrically with high time resolution to easily detect flares in order to check the flare frequencies, N_1 and N_2 .

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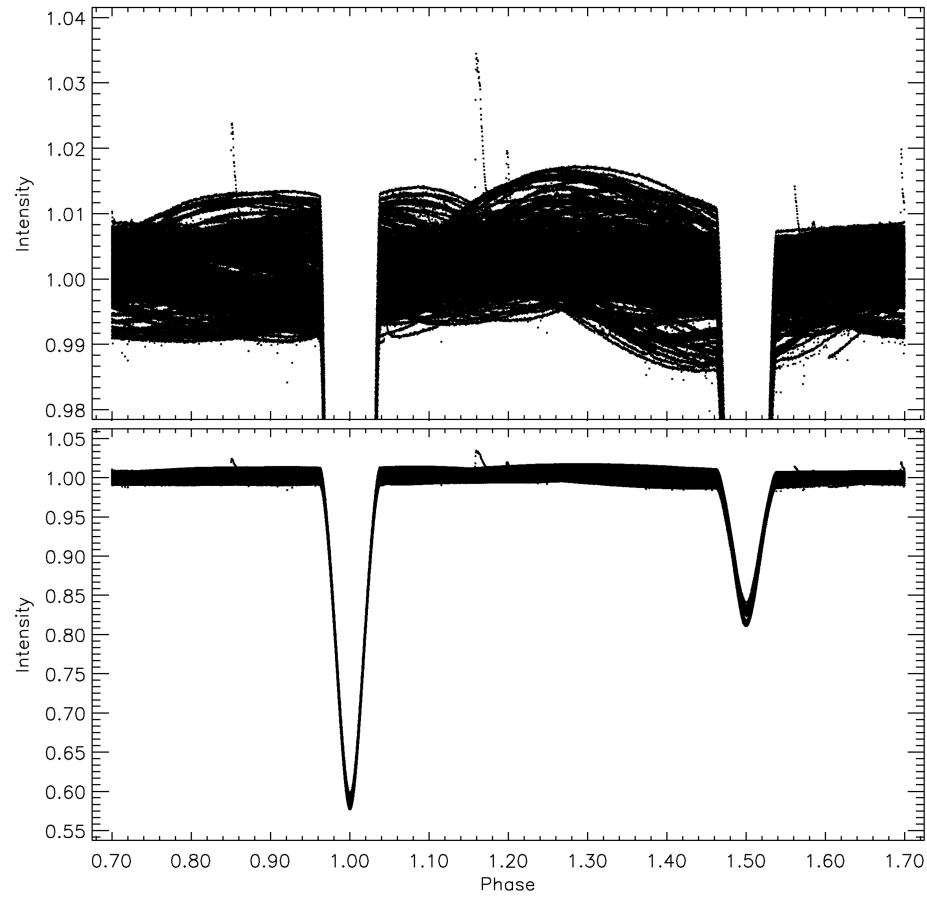


Figure 1: All the light curves obtained from the data given in the Kepler Mission Database are shown together with the error bars. The full of the light curves are shown in the bottom panel, while the maxima of the curves are shown in the upper panel to reveal the variations out of eclipses, such as sinusoidal variation due to the rotational modulation and sudden variations due to the flares.

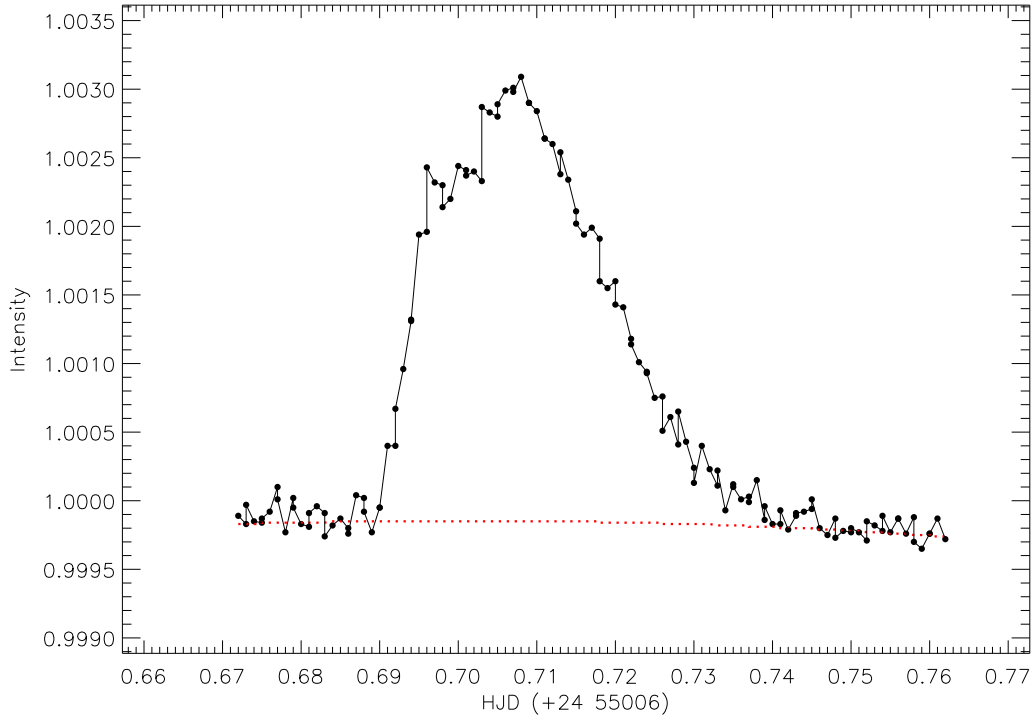


Figure 2: A slow flare example detected in the observations of the system. Filled circles show observations, while the dashed line represents the level of the quiescent state of the star for the observing night.

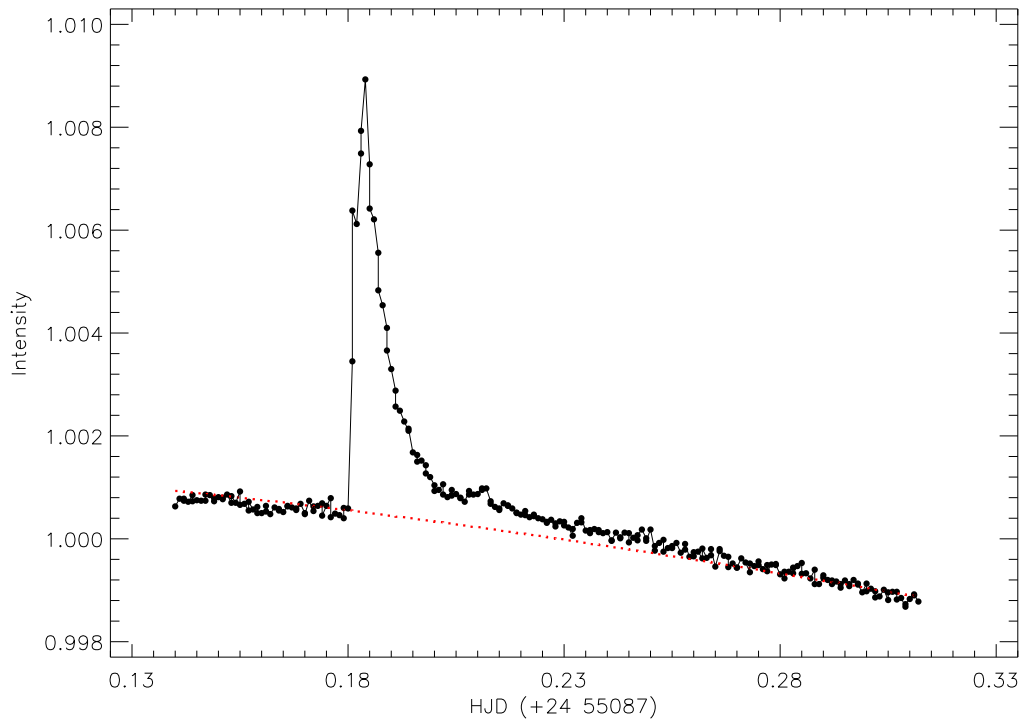


Figure 3: A fast flare example detected in the observations of the system. All the symbols are the same as in Figure 2.

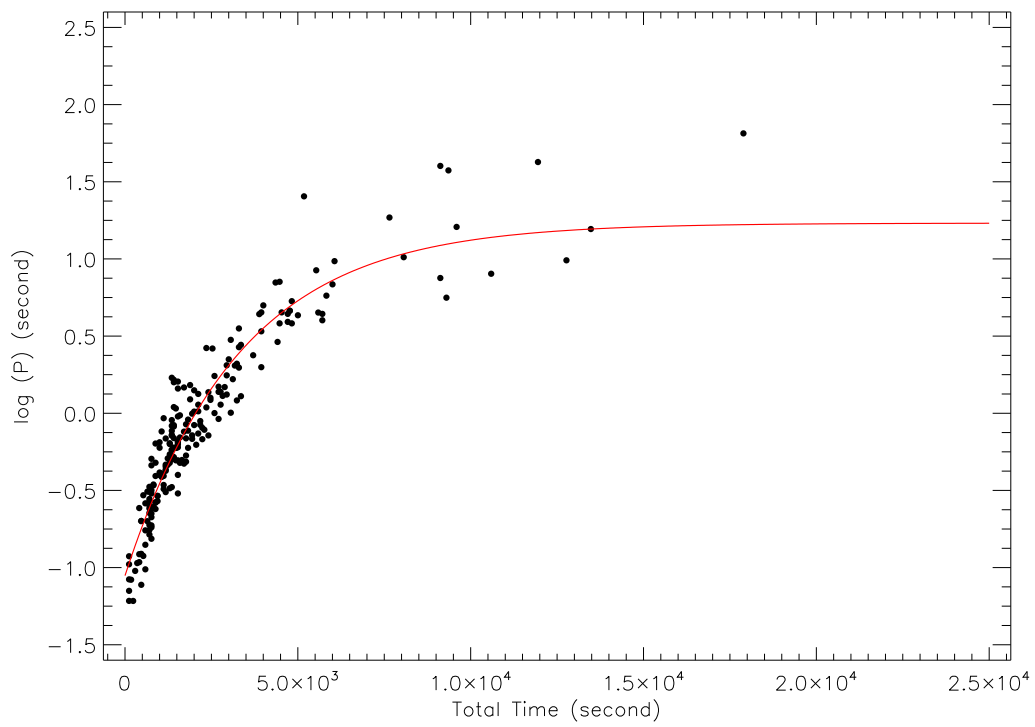


Figure 4: The distributions of flare equivalent durations on the logarithmic scale versus flare total durations for detected 240 flares and the OPEA model derived for this distribution. Filled circles show observed flares, while the line represents the OPEA model.

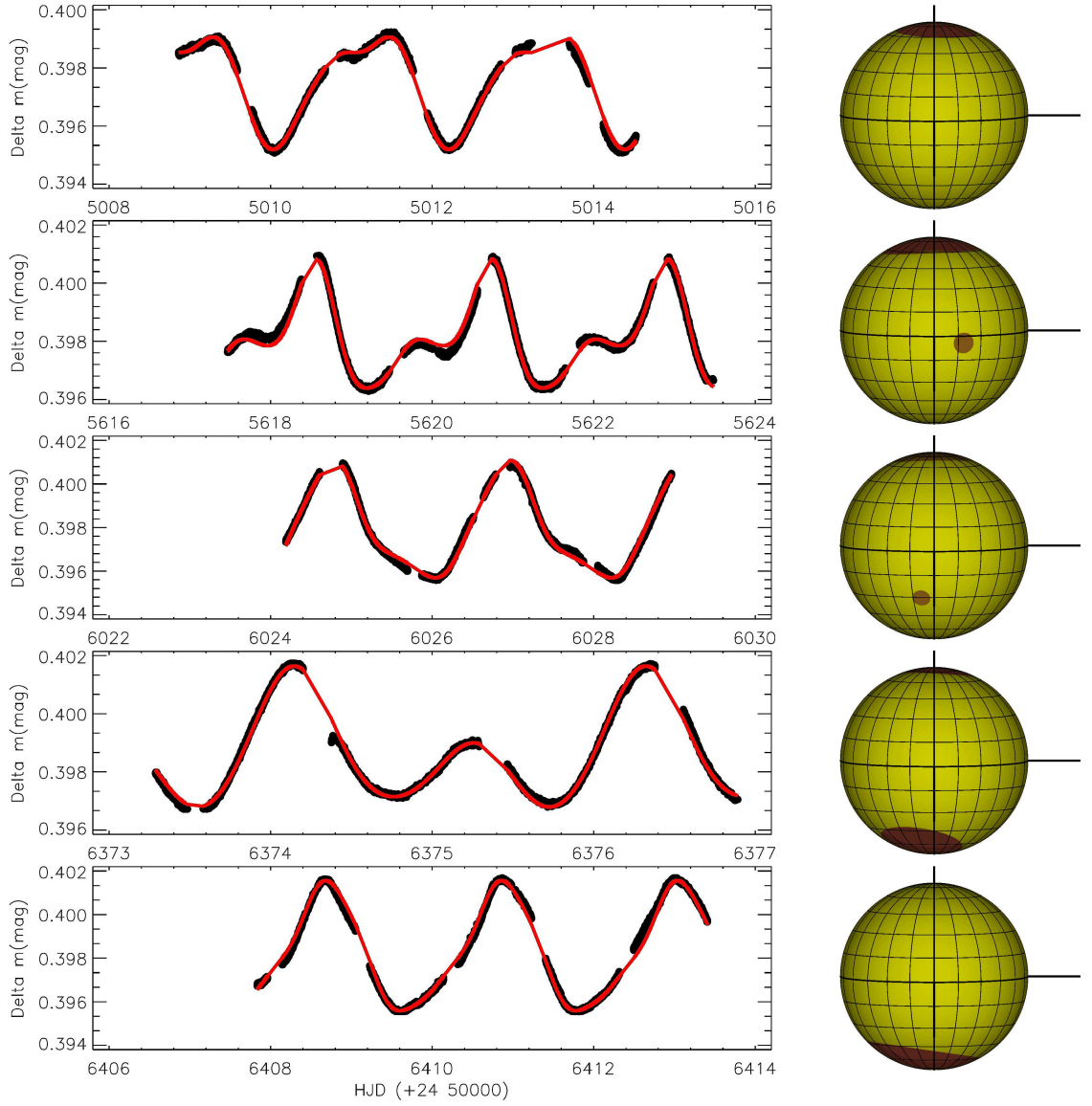


Figure 5: Some examples selected among all the models of rotation modulations due to cool spots. In the left panels, filled circles show observations arranged as the pre-whitened light curve, while the line represents the synthetic fits derived by the SPOTMODEL. In the right panels, the spot distributions on the active component surface derived by the SPOTMODEL are shown as the 3D form. In the figure, the pre-whitened light curve fit and its 3D model are shown side by side for the same sub-data set.

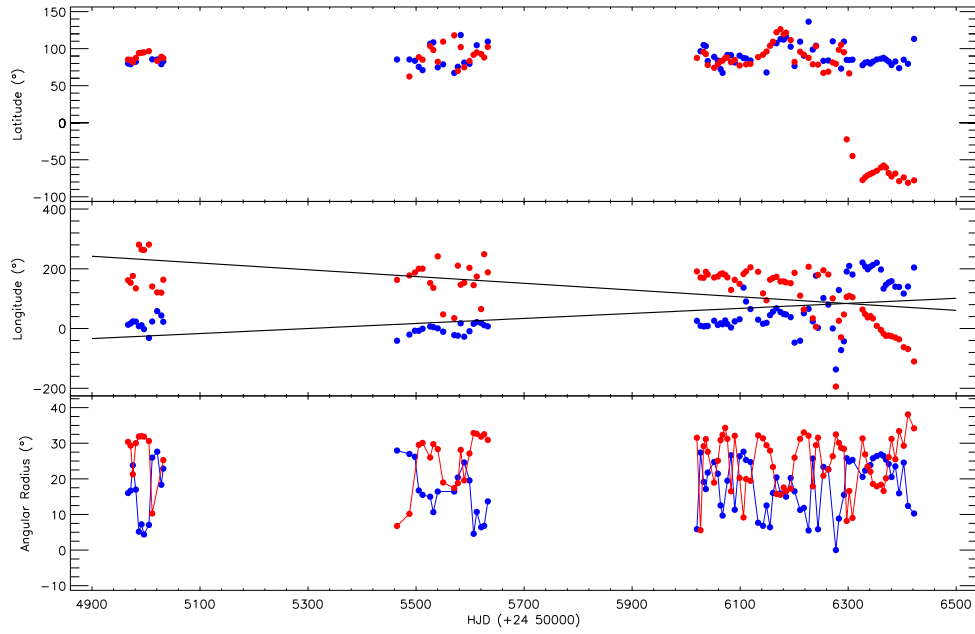


Figure 6: The variations of the parameters found by SPOTMODEL are shown. In the figure, filled red circles represent the Spot 1; filled blue circles represent the Spot 2. In the middle panel, two linear lines are shown just as the representative fits to the trends of spot longitudes. In the bottom panel, the filled circles are also consolidated with the thin lines to reveal the asynchronous trends between two spots.

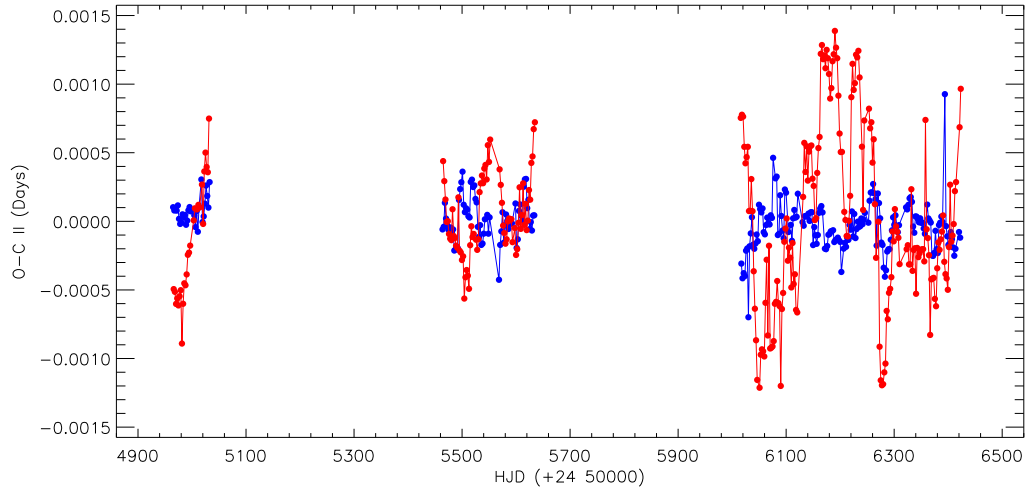


Figure 7: The variation of $(O - C)_{II}$ residuals obtained, after the linear correction on the $(O - C)_I$. In the figure, the filled blue circles represent the primary minima, while the filled red circles represent the secondary minima.

Table 1: Calculated Parameters of Flares Detected in the Observations of KIC 9641031.

Flare Time (+24 00000)	P (s)	T_r (s)	T_d (s)	Amplitude (Intensity)
54964.828101	0.463112	353.111616	882.763488	0.00085
54966.495541	0.108480	58.857408	353.111616	0.00134
54968.531480	0.326691	176.556672	1118.158560	0.00072
54969.875376	0.182262	235.395936	529.658784	0.00081
54970.999262	0.077346	235.405440	235.395936	0.00046
54972.743670	0.530361	411.951744	941.610528	0.00073
54974.041928	0.070687	58.848768	58.858272	0.00092
54975.767943	0.095177	117.706176	176.547168	0.00051
54976.821670	0.175537	117.707040	588.515328	0.00062
54978.267735	0.269551	294.261985	647.346816	0.00044
54978.968630	0.308382	235.395936	941.608800	0.00064
54979.569397	0.083443	58.848768	117.706176	0.00121
54981.868930	0.060800	117.697536	117.706175	0.00087
54982.271484	16.122205	1412.416224	8180.233632	0.00536
54983.156286	53.681508	294.253344	588.505824	0.04729
54984.105115	0.718312	353.101247	2059.777728	0.74619
54984.142578	0.187637	235.403712	529.647552	0.00056
54985.149985	0.495380	294.252480	1177.010784	0.00084
54987.513541	0.000915	294.243840	1059.312384	0.00092
54988.077524	0.122731	235.403712	235.403712	0.00061
54991.675301	0.656824	294.243840	1235.864736	0.00113
54992.740602	0.643601	294.243840	1235.864736	0.00138
54993.979592	0.060850	58.848768	58.847904	0.00100
54996.189202	1.588175	353.108160	1059.300288	0.00308
55002.563290	0.837296	411.947424	1000.448064	0.00180
55005.208137	0.503817	235.401984	1118.152512	0.00073
55006.581304	2.036945	765.061632	2412.847872	0.00144
55006.703908	7.032545	1235.848320	3119.061600	0.00298
55006.703908	0.431862	235.409760	941.589792	0.00125
55008.479624	0.596772	235.401984	1588.944384	0.00063
55012.644069	0.838489	235.409760	1765.485504	0.00098
55013.727750	1.522967	176.553216	1706.636736	0.00222
55018.755856	0.301985	235.391616	529.648416	0.00078
55019.661758	0.464195	176.552352	1000.439424	0.00060
55019.853156	1.073934	470.791872	1000.448064	0.00164
55022.582439	9.673752	529.647552	5531.844672	0.00802
55031.746995	0.302319	235.398528	1294.686720	0.00061
55032.350471	0.122125	117.703584	294.245568	0.00060
55032.359326	0.268830	176.541984	529.644096	0.00084
55467.694308	1.885821	470.779776	5060.842848	0.00075
55468.036220	0.224123	58.853952	706.161024	0.00061
55468.036220	0.224123	58.853952	706.161024	0.00061
55476.468224	3.544130	588.476448	2706.943968	0.00257
55477.348883	1.760652	2059.647264	882.702144	0.00122
55478.400497	0.423655	235.380384	941.546592	0.00117
55478.657271	0.478065	176.543712	706.149791	0.00107
55484.085612	0.298814	58.853088	58.836672	0.00497
55486.315520	0.178004	58.845312	58.844448	0.00292
55487.200944	0.242768	176.552352	588.466944	0.00062
55488.744307	0.200370	117.698400	353.077920	0.00084
55496.947413	0.224043	58.844448	58.845312	0.00387
55497.324058	0.310694	117.689760	529.620768	0.00147
55497.409194	0.264936	235.379520	647.318304	0.00100
55502.361430	4.615213	764.999424	4001.565888	0.00307
55486.315520	0.178004	58.845312	58.844448	0.00292
55487.200944	0.242768	176.552352	588.466944	0.00062
55488.744307	0.200370	117.698400	353.077920	0.00084
55496.947413	0.224043	58.844448	58.845312	0.00387
55497.324058	0.310694	117.689760	529.620768	0.00147
55497.409194	0.264936	235.379520	647.318304	0.00100
55502.361430	4.615213	764.999424	4001.565888	0.00307

Table 1: Continued From Previous Page.

Flare Time (+24 00000)	P (s)	T_r (s)	T_d (s)	Amplitude (Intensity)
55502.426134	0.105038	58.835808	58.844448	0.00146
55510.561799	0.243144	117.697536	294.223968	0.00140
55511.945101	0.118927	58.853952	470.765952	0.00041
55513.171751	0.225939	294.232608	411.922368	0.00092
55526.031492	37.460548	1706.544288	7650.056448	0.01375
55534.234607	0.386698	529.621632	529.622496	0.00080
55549.722099	0.601652	353.080512	1176.940800	0.00072
55551.038666	0.659278	117.699264	1412.331552	0.00116
55551.038666	0.953462	117.700128	1412.346240	0.00031
55569.559887	2.898580	353.083968	4060.501056	0.00178
55576.601875	0.909644	235.402848	1588.882176	0.00113
55582.646062	5.323281	353.078784	4472.468352	0.00574
55586.533182	0.648850	176.539392	823.869792	0.00165
55594.007077	0.183146	58.846176	58.855680	0.00309
55603.807709	5.780679	1765.470816	4060.584000	0.00210
55608.504741	1.975708	411.940512	2883.612960	0.00078
55611.104598	1.988434	1000.442880	2942.466048	0.00103
55614.553826	42.439277	529.638048	11416.792320	0.00962
55627.791601	0.233362	58.856544	58.847904	0.00394
55628.777201	0.153771	470.794464	294.249888	0.00043
55628.799678	0.174293	176.545440	411.945696	0.00051
55628.962469	0.679179	1471.257216	765.043488	0.00066
55629.928998	0.840648	353.097792	1824.339456	0.00089
55632.997510	0.804448	176.554080	2059.751808	0.00076
55633.814192	4.390032	353.107296	3530.997792	0.00593
55634.223554	0.628311	176.554080	1353.555360	0.00121
55634.564803	1.322826	235.393344	2707.121088	0.00151
56016.476472	0.168681	58.847904	58.848768	0.00268
56017.419168	65.836224	882.764352	26659.241856	0.02757
56019.800432	0.002725	235.412352	588.496320	0.00100
56021.131380	0.106976	58.848768	294.261120	0.00125
56021.204262	0.083883	58.848768	58.857408	0.00147
56022.705495	0.214953	58.857407	58.848768	0.00358
56022.742277	0.488879	58.848768	58.849632	0.00814
56026.543044	10.259427	1471.264992	6591.274560	0.00332
56030.632621	0.188793	176.555808	529.657920	0.00056
56030.681663	0.247377	235.404576	588.515328	0.00099
56033.568346	0.239645	235.404576	647.356320	0.00059
56033.717517	0.158799	58.848768	58.858272	0.00255
56033.992698	0.686340	117.706175	1059.308928	0.00167
56037.097350	0.097455	176.547168	411.952608	0.00034
56037.097350	0.199836	117.697536	529.650144	0.00070
56038.373132	0.343017	58.858272	1059.308928	0.00076
56039.407790	5.608481	529.667424	8768.766240	0.00147
56042.005674	0.000004	117.707040	647.357184	0.00132
56043.049187	3.516483	1118.168064	6885.547776	0.00086
56047.241632	40.052123	235.405440	8886.484512	0.02037
56048.921336	2.627696	529.660512	2000.932416	0.00241
56050.195758	0.260855	117.707040	470.802240	0.00109
56050.974307	0.291640	176.547168	765.065952	0.00072
56053.861001	6.842854	353.103840	5649.697728	0.00794
56054.345976	0.724180	176.555808	1177.019424	0.00106
56055.609501	1.368917	117.707040	2295.179712	0.00119
56056.725217	4.404903	353.103840	5355.434880	0.00289
56057.172730	1.029413	353.103840	1765.520064	0.00177
56057.934251	2.680671	470.810880	2824.841088	0.00175
56058.874231	15.620817	2824.849728	10652.029632	0.00267
56063.409979	1.136078	235.405440	1883.227104	0.00191
56069.179281	0.140559	117.707040	470.802240	0.00063
56069.447652	0.687776	353.103840	1412.432640	0.00081
56070.649873	0.716218	353.103840	1000.470528	0.00136

Table 1: Continued From Previous Page.

Flare Time (+24 00000)	P (s)	T_r (s)	T_d (s)	Amplitude (Intensity)
56071.401857	0.179078	58.848768	58.858272	0.00269
56075.048026	0.624893	294.254208	1765.526976	0.00082
56075.977108	1.646454	235.396800	1177.026336	0.00269
56079.256818	0.118439	58.849632	58.857408	0.00212
56080.711061	2.236179	176.548032	2824.835040	0.00262
56083.697196	9.794873	5178.865248	7591.754592	0.00238
56087.183969	7.111719	411.951744	4060.711872	0.00842
56095.037541	7.523292	3354.481728	5767.365024	0.00221
56095.794289	0.278405	117.688896	588.515328	0.00131
56096.232263	1.446169	117.697536	1412.407584	0.00408
56100.370875	18.548503	941.606208	6708.960864	0.01059
56103.321574	0.341100	176.554944	647.344224	0.00075
56104.969250	0.509812	294.242976	941.613984	0.00078
56109.139853	0.485133	411.949152	1353.560544	0.00067
56109.785572	1.408311	706.191264	1294.720416	0.00194
56111.547675	1.376109	647.359776	2059.758720	0.00157
56112.440646	4.493970	353.099520	5237.672544	0.00194
56113.543407	0.595973	235.401984	1235.844000	0.00133
56114.803510	8.016312	1059.306336	9533.724192	0.00175
56115.800012	2.774649	882.760896	2471.701824	0.00178
56132.752056	1.486270	176.552352	2530.537632	0.00156
56132.927787	1.091035	411.952608	1942.042176	0.00117
56135.367594	4.004825	1588.943520	4119.468192	0.00167
56136.515296	1.663035	647.334720	2471.684544	0.00112
56143.088859	0.413005	176.560129	823.883616	0.00106
56144.216803	3.457132	765.035712	5826.078144	0.00111
56147.055052	0.639562	294.245568	1000.441152	0.00094
56151.409477	2.444966	470.795328	4590.217728	0.00122
56155.667171	1.478003	529.641504	2353.945536	0.00117
56157.949606	4.405529	470.793600	4237.108704	0.00378
56158.279950	0.902990	117.702720	1235.831040	0.00239
56164.405252	2.045450	647.340767	2295.086400	0.00172
56170.504648	0.294271	353.088288	176.548896	0.00099
56172.716909	0.241851	470.789280	235.395072	0.00062
56173.721552	0.495333	117.701856	1412.359200	0.00092
56187.947916	0.521143	176.538528	1118.108448	0.00064
56188.426054	0.598732	294.230016	1118.116224	0.00108
56188.966173	0.631781	235.392480	1059.253632	0.00107
56190.499346	1.260252	765.014976	1706.574528	0.00098
56194.364625	3.822607	706.166208	4119.327360	0.00184
56195.547706	1.025324	176.554944	1824.261696	0.00124
56197.199385	2.376246	1059.257088	2648.134944	0.00100
56199.549877	0.392141	117.700128	765.010656	0.00114
56199.675200	0.541799	353.082240	941.564736	0.00140
56201.810459	0.345300	235.382976	588.472992	0.00087
56202.508590	1.289982	235.382112	3118.909536	0.00092
56211.433042	0.253313	235.381248	470.771136	0.00091
56212.912391	0.398212	117.699264	882.704736	0.00165
56212.984587	0.636392	117.690624	765.005472	0.00138
56219.273174	1.744263	235.397664	2353.874688	0.00374
56221.997566	0.332327	235.380384	1118.091168	0.00068
56227.370058	0.532126	235.389024	1530.012672	0.00084
56228.156724	1.002638	353.086560	2236.169376	0.00142
56228.538819	0.771124	117.699264	1706.546880	0.00137
56230.928104	0.291106	117.698400	823.846464	0.00064
56231.936807	0.781827	411.922368	1883.098368	0.00074
56232.299149	1.096483	176.542848	1235.777472	0.00220
56232.446266	0.497900	117.689760	1530.010944	0.00078
56233.019067	0.477360	294.223968	1294.640064	0.00074
56235.193123	0.918914	470.776320	2236.165920	0.00078
56238.375199	2.646142	176.542848	2177.328384	0.00512

Table 1: Continued From Previous Page.

Flare Time (+24 00000)	P (s)	T_r (s)	T_d (s)	Amplitude (Intensity)
56240.689558	1.698398	235.396800	1118.085984	0.00343
56253.134493	0.579830	235.387296	1118.076480	0.00077
56253.270712	3.909380	235.396800	4472.339616	0.00261
56253.708655	0.577834	235.387296	1118.085120	0.00088
56253.764505	0.333632	235.378656	470.775456	0.00092
56259.634853	0.519913	588.456575	823.862016	0.00058
56263.408795	4.314619	764.999424	4236.946272	0.00161
56265.192581	0.829487	117.698400	1235.775744	0.00145
56266.091626	5.000047	235.379520	3766.171680	0.00566
56266.690989	1.376481	353.077056	2412.707040	0.00102
56268.161472	0.762166	117.698400	941.543136	0.00208
56272.319556	0.697019	294.241248	1294.621920	0.00087
56279.123704	1.220712	176.543712	2295.023328	0.00140
56279.983247	0.739083	117.689760	2000.790720	0.00085
56280.433452	0.821007	176.543712	1235.771424	0.00179
56286.625990	1.469311	117.699264	1588.853664	0.00354
56291.777822	2.093364	58.845312	3177.730657	0.00129
56296.087824	0.969906	294.236064	1294.640928	0.00194
56301.549580	4.504331	353.082240	3589.690177	0.00438
56305.497216	3.824587	588.482496	3883.926240	0.00293
56307.391368	1.230758	235.391616	1647.732672	0.00208
56327.035909	0.719264	353.096064	1588.889088	0.00087
56327.035909	25.439798	353.096928	4825.556640	0.01881
56336.668926	2.989529	353.090016	2707.022592	0.00263
56339.221077	1.136775	235.387296	2530.496160	0.00131
56339.541884	1.604309	411.937056	1118.126592	0.00270
56345.040568	0.477432	411.938784	882.724608	0.00092
56345.307568	0.392422	176.549760	941.589792	0.00070
56349.715794	0.163734	235.406304	470.787552	0.00058
56352.338123	0.323102	117.703584	1000.432512	0.00072
56353.343464	1.210804	529.644960	2707.070976	0.00094
56353.736473	0.690799	117.686304	1294.697088	0.00102
56354.213942	0.993478	529.636320	1412.392032	0.00111
56354.931168	0.406601	235.398528	823.882752	0.00080
56359.817574	1.007938	294.255936	2765.921472	0.00070
56360.278698	0.597696	235.399392	765.038304	0.00161
56360.297769	0.760295	294.239520	1412.388576	0.00112
56360.603596	4.503978	647.342496	3884.073984	0.00295
56361.760834	0.596414	117.704448	1353.533760	0.00116
56361.861641	0.459723	235.390752	529.647552	0.00122
56361.882075	0.506702	117.695808	647.343360	0.00218
56384.711629	8.440221	294.259392	5237.676864	0.00740
56386.072543	0.471606	176.554944	1530.105984	0.00075
56386.759811	1.334255	176.554080	1942.064640	0.00178
56387.568322	0.682612	176.554944	1765.510560	0.00112
56390.454308	0.212132	235.395072	529.655328	0.00062
56392.943840	0.316764	117.706176	647.361504	0.00079
56393.122299	1.295137	529.656192	2295.162432	0.00098
56393.208804	0.890257	235.412352	1942.061184	0.00103
56395.091476	0.310735	176.546304	529.657056	0.00110
56397.452991	0.451218	353.110752	823.910400	0.00085
56397.766998	2.049632	353.102112	4708.047456	0.00086
56403.314898	0.769157	117.698400	1235.871648	0.00257
56405.543598	0.848409	411.951744	1353.561408	0.00087
56408.559018	0.398574	117.707040	1412.420544	0.00051
56410.992064	0.928899	176.565312	941.601888	0.00205
56423.590507	3.395311	411.969888	3531.047040	0.00240

Table 2: The OPEA model parameters by using the least-squares method.

Parameter	Values	95 Confidence Intervals
y_0	-1.052 ± 0.037	-1.1255 to -0.979
$Plateau$	1.232 ± 0.069	1.097 to 1.368
K	0.0003 ± 0.0001	0.0003 to 0.0003
τ	3306.2	2904.7 to 3836.5
$Half - life$	2291.7	2013.4 to 2659.3
$Span$	2.285 ± 0.061	2.165 to 2.405
Goodness of Fit	Method	Values
R^2		0.9010
$p - value$	(D'Agostino-Pearson)	0.0010
$p - value$	(Shapiro-Wilk)	0.0005
$p - value$	(Kolmogorov-Smirnov)	0.0007

Table 3: The spot parameters obtained from the SPOTMODEL program.

HJD Average (+24 00000)	b_{Spot1} (degree)	b_{Spot2} (degree)	g_{Spot1} (degree)	g_{Spot2} (degree)	l_{Spot1} (degree)	l_{Spot2} (degree)
54966.748617	79.990±1.342	85.249±0.731	16.027±1.850	30.379±0.971	12.693±1.401	161.691±1.850
54971.548427	79.017±1.211	84.899±0.691	16.679±1.837	29.342±0.992	17.008±1.682	153.193±1.872
54975.579032	82.600±0.455	81.536±0.925	23.829±0.674	21.287±1.410	23.755±1.304	176.001±1.927
54981.174707	82.324±0.477	87.351±1.216	16.995±0.695	30.032±1.431	23.148±1.325	134.470±1.948
54986.814506	83.559±0.498	94.028±0.012	5.178±0.135	31.869±0.016	7.753±0.163	280.838±0.447
54991.711822	84.793±0.519	94.365±0.012	7.237±0.999	31.994±0.011	10.958±0.163	264.416±0.298
54996.265208	86.028±0.540	95.018±0.020	4.369±0.155	31.863±0.030	-2.015±0.320	262.798±0.653
55005.446506	87.262±1.692	96.681±0.033	7.079±0.223	30.620±0.027	-31.374±0.249	281.165±0.295
55011.432468	85.578±0.016	97.915±0.695	25.965±0.015	10.282±0.151	23.549±0.293	140.682±0.111
55020.696339	85.350±0.051	83.381±0.717	27.633±0.070	11.516±0.172	58.242±1.070	120.986±0.132
55028.344387	79.046±1.578	89.011±0.420	18.344±0.091	12.751±0.193	43.644±1.058	120.105±0.154
55031.989276	83.000±1.599	87.135±0.441	22.889±0.113	25.257±0.214	22.590±1.079	163.223±0.175
55464.747687	85.319±0.020	88.369±0.462	27.958±0.011	6.779±0.191	-40.900±0.125	162.924±0.172
55487.675251	85.336±0.040	62.394±1.065	26.981±0.023	10.179±0.277	-20.300±0.177	177.745±0.175
55497.802773	83.590±0.024	63.629±1.086	26.207±0.013	11.413±0.170	-7.418±0.087	187.434±0.221
55504.991926	75.462±0.659	88.484±0.458	16.744±0.896	29.556±0.477	-7.509±0.140	200.188±0.242
55512.008636	71.005±0.387	85.027±0.163	15.506±0.284	30.105±0.122	-0.756±0.089	200.467±0.684
55526.123227	106.593±0.466	103.531±0.208	14.989±0.294	25.988±0.159	6.903±0.399	152.267±0.455
55531.947550	108.480±0.538	98.160±0.059	10.654±0.241	29.757±0.052	4.651±0.249	136.196±0.405
55540.150265	74.758±0.722	82.278±0.297	16.441±0.771	28.348±0.430	0.526±0.984	241.613±0.426
55550.120846	78.770±0.105	109.450±0.322	17.676±0.109	18.982±0.262	-10.684±0.551	47.313±0.421
55570.653552	67.227±0.163	117.938±0.272	-16.453±0.073	17.409±0.106	-22.100±0.167	34.813±0.203
55577.332141	75.537±0.106	69.893±0.261	20.383±0.087	18.810±0.176	-23.898±0.330	210.453±0.345
55582.640857	118.386±0.582	102.093±0.049	21.617±0.147	28.144±0.036	17.583±0.137	146.621±0.193
55589.146197	81.138±0.248	74.800±0.631	24.593±0.252	19.583±0.665	-27.237±1.014	553.075±0.781
55598.882642	79.524±0.948	83.258±0.917	19.567±1.416	27.130±1.225	-9.082±1.471	203.290±0.802
55606.616321	80.759±0.969	91.696±0.021	4.582±0.166	32.870±0.016	15.910±0.229	145.193±0.786
55612.337192	104.601±1.503	94.891±0.211	10.725±0.936	32.637±0.172	21.585±0.514	173.870±1.225
55620.453150	105.836±1.524	92.835±0.021	6.429±0.055	31.846±0.015	18.541±0.081	65.127±0.406
55626.068455	107.070±1.563	88.134±0.017	6.811±0.119	32.532±0.015	11.192±0.098	248.859±0.726
55632.806400	109.578±0.657	102.330±0.163	13.680±0.321	30.920±0.101	7.339±0.100	188.091±0.062
56019.935539	110.813±0.679	87.468±0.040	5.875±0.160	31.542±0.020	25.791±0.140	191.137±0.401
56026.670560	96.499±0.017	88.703±0.061	27.398±0.009	5.585±1.298	9.290±0.072	170.818±0.215
56032.419541	104.936±0.810	95.551±0.739	19.146±0.981	29.178±0.701	7.002±0.312	169.842±0.237
56036.438862	103.385±1.923	92.710±1.387	17.135±1.002	31.151±1.376	8.342±0.251	189.997±1.131
56039.995372	83.216±0.700	77.867±0.603	21.748±0.845	27.608±0.872	8.456±0.609	180.911±0.249
56051.904498	88.923±0.455	74.171±0.983	24.750±0.510	18.939±1.463	26.078±0.630	170.835±0.216
56058.709566	83.974±0.420	78.639±0.424	21.434±0.530	25.099±0.645	11.755±0.962	174.431±0.374
56063.740465	72.375±0.414	82.975±0.089	12.557±0.232	30.903±0.063	17.489±0.102	182.573±0.189
56067.478165	67.309±0.410	83.842±0.030	9.687±0.124	32.378±0.018	14.197±0.091	184.618±0.067
56072.319884	68.543±0.432	87.319±0.018	10.922±0.203	34.317±0.010	27.157±0.341	179.432±0.203
56076.369572	91.526±0.453	87.817±0.039	19.478±0.224	31.233±0.031	14.791±0.362	171.271±0.225
56083.175187	91.141±1.752	81.716±0.060	26.639±0.245	16.500±0.053	3.413±0.383	129.074±0.246
56090.021171	81.368±1.642	84.691±0.309	11.326±0.266	32.092±0.436	23.959±0.404	162.936±0.267
56098.945279	90.561±0.568	77.197±1.733	26.359±1.467	20.293±0.458	31.063±0.425	149.649±0.593
56106.238782	87.355±0.028	78.432±1.194	27.631±0.021	9.173±0.284	137.026±0.619	182.468±0.170
56110.914339	86.740±0.315	78.744±1.574	25.308±1.389	19.960±0.305	90.403±0.641	191.217±0.191
56119.146386	83.948±0.484	79.424±1.212	24.718±0.699	19.449±1.888	65.174±0.662	204.809±0.213
56133.285043	85.182±1.012	88.629±0.029	7.669±0.130	32.215±0.019	29.521±0.101	190.022±0.544
56142.330996	86.417±1.574	91.767±0.015	6.815±0.183	31.389±0.021	15.946±0.164	117.758±1.230
56148.859429	67.827±0.564	96.140±0.044	12.529±0.268	29.421±0.079	19.233±0.230	94.463±1.031
56155.366816	69.061±0.585	103.871±0.047	6.417±0.015	27.936±0.032	44.780±0.142	163.471±0.155
56160.755894	108.042±0.521	109.393±0.298	16.044±0.358	23.355±0.280	56.483±1.097	168.932±0.895
56167.279388	107.298±0.052	122.043±0.292	20.417±0.041	15.773±0.107	67.821±0.178	173.140±0.161
56174.646136	112.920±0.229	126.288±0.482	15.899±0.106	15.524±0.148	55.323±0.321	157.713±0.263
56180.652267	112.127±0.310	119.125±0.469	17.134±0.150	17.568±0.201	48.533±0.459	157.771±0.412
56184.967399	115.987±0.589	121.574±0.802	14.996±0.225	16.467±0.288	47.125±0.558	154.397±0.572
56193.553737	102.635±0.165	111.570±0.587	20.218±0.163	17.251±0.383	38.112±0.877	151.783±0.691
56200.757825	76.503±0.837	82.036±0.489	16.495±0.937	25.972±0.631	-47.179±1.390	186.476±0.712

Table 3: Continued From Previous Page.

HJD Average (+24 00000)	b_{Spot1} (degree)	b_{Spot2} (degree)	g_{Spot1} (degree)	g_{Spot2} (degree)	l_{Spot1} (degree)	l_{Spot2} (degree)
56211.056479	109.417±0.645	95.809±0.082	11.278±0.289	31.234±0.062	-40.907±0.174	110.014±0.396
56217.956451	90.533±0.667	91.914±0.103	11.858±0.310	33.040±0.083	51.011±0.195	63.843±0.417
56226.753235	136.389±0.688	87.493±0.039	5.517±0.328	32.116±0.032	66.005±0.302	206.760±0.955
56234.493888	98.779±0.482	78.880±1.577	25.698±0.496	17.890±1.707	23.892±0.485	34.233±0.905
56240.418359	103.924±1.839	103.262±0.524	26.932±1.149	29.476±0.381	177.001±0.509	5.803±0.294
56244.159299	105.159±1.860	78.451±0.023	5.854±0.857	31.548±0.012	2.399±0.126	179.182±0.050
56254.131126	83.551±0.057	67.202±0.411	23.366±0.207	20.878±0.441	102.151±0.147	195.064±0.410
56263.188537	84.022±0.115	68.895±0.371	22.682±0.285	22.626±0.483	79.998±0.168	180.925±0.454
56271.454008	109.887±0.588	81.309±0.048	23.916±0.613	26.347±0.414	0.181±0.790	100.857±0.475
56277.288435	111.122±0.610	79.497±0.045	0.020±0.634	32.491±0.046	-136.998±0.811	-194.250±0.405
56282.783429	112.356±0.631	98.366±0.029	8.853±1.224	30.135±0.033	128.827±0.166	26.035±0.352
56286.913227	73.066±0.979	105.193±0.221	10.087±0.528	28.728±0.180	-72.327±0.885	-29.505±0.576
56292.187548	109.487±1.006	95.071±0.077	15.514±0.845	28.434±0.415	-42.821±0.564	46.974±0.597
56297.298298	84.828±0.017	-22.476±0.099	25.797±0.019	8.175±1.224	190.768±0.353	105.561±0.125
56301.917977	84.573±0.034	66.599±0.434	24.865±0.074	16.595±0.289	209.708±1.092	109.378±0.204
56308.021249	85.108±0.017	-45.013±0.455	25.322±0.025	9.039±1.696	180.859±0.485	104.722±0.182
56326.631702	77.649±0.291	-77.372±0.284	20.539±0.273	31.359±0.304	220.983±0.354	63.363±0.366
56331.357357	81.006±0.231	-73.662±0.324	22.326±0.190	26.886±0.364	208.129±0.490	48.290±0.256
56336.183459	81.731±0.096	-70.981±0.198	23.303±0.067	23.446±0.197	198.238±0.202	37.170±0.109
56341.198233	79.838±0.062	-69.168±0.183	23.865±0.039	22.024±0.150	207.109±0.090	41.906±0.087
56345.884105	82.507±0.040	-67.521±0.229	25.796±0.024	18.556±0.164	212.947±0.069	33.673±0.105
56353.018823	85.351±0.055	-64.809±0.385	26.421±0.034	17.906±0.263	220.314±0.401	8.933±0.117
56360.668713	86.436±0.029	-60.461±0.215	26.880±0.017	18.362±0.125	197.621±0.196	-4.560±0.045
56365.601473	87.527±0.019	-57.768±0.296	26.443±0.013	16.613±0.132	133.622±0.300	-17.267±0.049
56369.951021	85.361±0.029	-60.548±0.152	25.421±0.018	20.182±0.093	146.536±0.106	-24.466±0.045
56375.100519	82.630±0.101	-67.948±0.150	24.183±0.066	26.110±0.155	154.421±0.102	-23.394±0.050
56380.272754	77.911±0.246	-72.538±0.222	20.510±0.183	31.218±0.206	158.492±0.122	-25.727±0.081
56387.350166	82.601±0.104	-68.587±0.161	23.519±0.070	25.517±0.164	140.132±0.147	-30.362±0.062
56394.302243	73.643±0.854	-78.854±0.394	15.956±0.568	33.415±0.319	139.120±0.196	-36.286±0.202
56402.891002	85.066±0.498	-73.759±0.544	24.570±0.454	29.288±0.849	116.964±0.324	-62.468±0.154
56410.718694	79.538±1.771	-81.052±0.377	12.399±1.618	38.090±0.421	140.446±1.752	-68.613±1.076
56421.983368	113.074±0.592	-77.756±0.051	10.277±0.181	34.187±0.041	204.234±0.224	-110.244±0.177

Table 4: Minima times and $(O - C)_I$ and $(O - C)_{II}$ residuals.

HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)	HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)
54965.02435	5.0	I	0.00087	0.00010	56094.39675	523.5	II	0.00026	-0.00052
54966.11283	5.5	II	0.00027	-0.00049	56095.48623	524.0	I	0.00066	-0.00012
54967.20248	6.0	I	0.00084	0.00008	56096.57528	524.5	II	0.00064	-0.00015
54968.29097	6.5	II	0.00025	-0.00051	56097.66474	525.0	I	0.00102	0.00023
54969.38064	7.0	I	0.00085	0.00009	56098.75353	525.5	II	0.00073	-0.00005
54970.46903	7.5	II	0.00016	-0.00060	56099.84287	526.0	I	0.00100	0.00021
54971.55879	8.0	I	0.00084	0.00008	56100.93176	526.5	II	0.00081	0.00002
54972.64723	8.5	II	0.00020	-0.00056	56103.10961	527.5	II	0.00050	-0.00029
54973.73698	9.0	I	0.00088	0.00012	56104.19889	528.0	I	0.00071	-0.00008
54974.82533	9.5	II	0.00015	-0.00061	56105.28786	528.5	II	0.00059	-0.00019
54975.91504	10.0	I	0.00078	0.00002	56107.46594	529.5	II	0.00052	-0.00027
54977.00355	10.5	II	0.00022	-0.00055	56108.55525	530.0	I	0.00076	-0.00003
54978.09316	11.0	I	0.00075	-0.00002	56109.64387	530.5	II	0.00030	-0.00048
54979.18175	11.5	II	0.00026	-0.00050	56110.73329	531.0	I	0.00064	-0.00014
54980.27132	12.0	I	0.00076	-0.00001	56111.82235	531.5	II	0.00063	-0.00016
54981.35952	12.5	II	-0.00013	-0.00089	56112.91161	532.0	I	0.00081	0.00002
54982.44953	13.0	I	0.00082	0.00005	56114.00021	532.5	II	0.00033	-0.00046
54983.53796	13.5	II	0.00016	-0.00060	56115.08982	533.0	I	0.00087	0.00008
54984.62767	14.0	I	0.00080	0.00003	56116.17843	533.5	II	0.00040	-0.00039
54985.71626	14.5	II	0.00031	-0.00045	56117.26792	534.0	I	0.00081	0.00003
54986.80584	15.0	I	0.00081	0.00005	56118.35633	534.5	II	0.00014	-0.00065
54987.89440	15.5	II	0.00030	-0.00047	56119.44608	535.0	I	0.00082	0.00003
54988.98392	16.0	I	0.00074	-0.00003	56120.53446	535.5	II	0.00012	-0.00066
54990.07264	16.5	II	0.00038	-0.00039	56121.62441	536.0	I	0.00099	0.00020
54991.16211	17.0	I	0.00077	0.00001	56130.33682	540.0	I	0.00078	-0.00001
54992.25093	17.5	II	0.00052	-0.00024	56131.42608	540.5	II	0.00097	0.00018
54993.34034	18.0	I	0.00084	0.00008	56132.51494	541.0	I	0.00076	-0.00003
54994.42910	18.5	II	0.00054	-0.00023	56133.60463	541.5	II	0.00136	0.00057
54995.51851	19.0	I	0.00087	0.00010	56134.69317	542.0	I	0.00083	0.00004
54996.60731	19.5	II	0.00059	-0.00018	56135.78257	542.5	II	0.00115	0.00036
54997.69664	20.0	I	0.00084	0.00007	56136.87132	543.0	I	0.00082	0.00003
55003.14196	22.5	II	0.00077	0.00001	56137.96091	543.5	II	0.00133	0.00055
55004.23107	23.0	I	0.00081	0.00004	56140.13881	544.5	II	0.00108	0.00030
55005.32020	23.5	II	0.00086	0.00010	56141.22765	545.0	I	0.00084	0.00006
55006.40914	24.0	I	0.00072	-0.00004	56142.31718	545.5	II	0.00130	0.00051
55007.49835	24.5	II	0.00085	0.00009	56143.40575	546.0	I	0.00079	0.00000
55008.58741	25.0	I	0.00084	0.00008	56144.49537	546.5	II	0.00133	0.00055
55009.67650	25.5	II	0.00085	0.00009	56145.58397	547.0	I	0.00085	0.00007
55010.76541	26.0	I	0.00069	-0.00008	56146.67353	547.5	II	0.00134	0.00055
55011.85469	26.5	II	0.00089	0.00012	56147.76212	548.0	I	0.00085	0.00007
55012.94375	27.0	I	0.00087	0.00011	56148.85144	548.5	II	0.00110	0.00031
55014.03282	27.5	II	0.00087	0.00010	56149.94004	549.0	I	0.00061	-0.00017
55017.30026	29.0	I	0.00107	0.00031	56151.02955	549.5	II	0.00105	0.00026
55018.38930	29.5	II	0.00103	0.00027	56152.11832	550.0	I	0.00075	-0.00004
55019.47810	30.0	I	0.00076	-0.00001	56153.20745	550.5	II	0.00080	0.00001
55020.56717	30.5	II	0.00075	-0.00002	56154.29642	551.0	I	0.00069	-0.00010
55021.65630	31.0	I	0.00080	0.00004	56155.38562	551.5	II	0.00081	0.00002
55022.74570	31.5	II	0.00113	0.00036	56156.47451	552.0	I	0.00062	-0.00016
55023.83455	32.0	I	0.00089	0.00013	56157.56410	552.5	II	0.00114	0.00035
55024.92399	32.5	II	0.00127	0.00050	56158.65273	553.0	I	0.00069	-0.00010
55026.01283	33.0	I	0.00103	0.00026	56159.74244	553.5	II	0.00132	0.00053
55027.10204	33.5	II	0.00116	0.00040	56160.83105	554.0	I	0.00085	0.00006
55028.19091	34.0	I	0.00095	0.00019	56161.92067	554.5	II	0.00140	0.00062
55029.28016	34.5	II	0.00112	0.00036	56163.00923	555.0	I	0.00088	0.00009
55030.36898	35.0	I	0.00087	0.00010	56164.09944	555.5	II	0.00201	0.00122
55031.45871	35.5	II	0.00151	0.00075	56165.18740	556.0	I	0.00090	0.00011
55032.54732	36.0	I	0.00105	0.00029	56166.27785	556.5	II	0.00227	0.00129
55463.82153	234.0	I	0.00072	-0.00006	56167.36551	557.0	I	0.00085	0.00007
55464.91111	234.5	II	0.00121	0.00044	56168.45620	557.5	II	0.00247	0.00118

Table 4: Continued From Previous Page.

HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)	HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)
55465.99971	235.0	I	0.00073	-0.00004	56170.63419	558.5	II	0.00230	0.00121
55467.08912	235.5	II	0.00107	0.00029	56171.72156	559.0	I	0.00059	-0.00020
55468.17804	236.0	I	0.00091	0.00014	56172.81225	559.5	II	0.00220	0.00112
55469.26714	236.5	II	0.00093	0.00016	56173.89971	560.0	I	0.00058	-0.00020
55470.35608	237.0	I	0.00079	0.00002	56174.99024	560.5	II	0.00204	0.00125
55471.44513	237.5	II	0.00077	0.00000	56176.07788	561.0	I	0.00061	-0.00018
55472.53418	238.0	I	0.00075	-0.00003	56177.16833	561.5	II	0.00198	0.00119
55473.62329	238.5	II	0.00078	0.00000	56178.25612	562.0	I	0.00069	-0.00010
55474.71230	239.0	I	0.00071	-0.00006	56179.34637	562.5	II	0.00186	0.00107
55475.80135	239.5	II	0.00068	-0.00009	56180.43428	563.0	I	0.00070	-0.00009
55476.89046	240.0	I	0.00071	-0.00006	56181.52434	563.5	II	0.00168	0.00090
55477.97947	240.5	II	0.00065	-0.00013	56182.61245	564.0	I	0.00072	-0.00007
55479.06863	241.0	I	0.00073	-0.00005	56183.70257	564.5	II	0.00176	0.00097
55480.15761	241.5	II	0.00064	-0.00014	56184.79061	565.0	I	0.00072	-0.00007
55481.24674	242.0	I	0.00069	-0.00008	56185.88092	565.5	II	0.00196	0.00117
55482.33599	242.5	II	0.00086	0.00009	56186.96877	566.0	I	0.00072	-0.00007
55483.42492	243.0	I	0.00072	-0.00006	56188.05913	566.5	II	0.00201	0.00122
55484.51395	243.5	II	0.00067	-0.00011	56189.14684	567.0	I	0.00064	-0.00015
55485.60292	244.0	I	0.00056	-0.00021	56190.23745	567.5	II	0.00218	0.00139
55486.69209	244.5	II	0.00065	-0.00012	56191.32501	568.0	I	0.00065	-0.00014
55487.78109	245.0	I	0.00057	-0.00021	56192.41549	568.5	II	0.00205	0.00127
55488.87019	245.5	II	0.00060	-0.00018	56193.50316	569.0	I	0.00065	-0.00014
55489.95926	246.0	I	0.00059	-0.00019	56194.59356	569.5	II	0.00198	0.00119
55491.04833	246.5	II	0.00058	-0.00019	56195.68133	570.0	I	0.00067	-0.00012
55492.13740	247.0	I	0.00058	-0.00020	56196.77145	570.5	II	0.00170	0.00092
55493.22685	247.5	II	0.00095	0.00018	56197.85947	571.0	I	0.00065	-0.00014
55494.31591	248.0	I	0.00093	0.00016	56198.94932	571.5	II	0.00143	0.00064
55495.40462	248.5	II	0.00056	-0.00021	56200.03761	572.0	I	0.00064	-0.00015
55496.49414	249.0	I	0.00101	0.00024	56201.12734	572.5	II	0.00129	0.00051
55497.58276	249.5	II	0.00055	-0.00023	56202.21555	573.0	I	0.00042	-0.00037
55498.67235	250.0	I	0.00106	0.00029	56203.30550	573.5	II	0.00129	0.00051
55499.76086	250.5	II	0.00049	-0.00028	56206.57202	575.0	I	0.00059	-0.00020
55500.85058	251.0	I	0.00114	0.00036	56207.66137	575.5	II	0.00086	0.00007
55501.93904	251.5	II	0.00052	-0.00026	56208.75022	576.0	I	0.00063	-0.00016
55503.02849	252.0	I	0.00090	0.00012	56209.83947	576.5	II	0.00080	0.00001
55504.11689	252.5	II	0.00021	-0.00056	56210.92835	577.0	I	0.00060	-0.00019
55505.20659	253.0	I	0.00084	0.00007	56212.01750	577.5	II	0.00068	-0.00011
55506.29519	253.5	II	0.00037	-0.00041	56213.10657	578.0	I	0.00067	-0.00012
55507.38477	254.0	I	0.00087	0.00010	56214.19565	578.5	II	0.00068	-0.00011
55508.47340	254.5	II	0.00042	-0.00036	56215.28471	579.0	I	0.00065	-0.00014
55509.56292	255.0	I	0.00086	0.00009	56216.37392	579.5	II	0.00079	0.00000
55510.65152	255.5	II	0.00038	-0.00040	56217.46297	580.0	I	0.00076	-0.00003
55511.74103	256.0	I	0.00081	0.00004	56218.55226	580.5	II	0.00097	0.00019
55512.82957	256.5	II	0.00028	-0.00049	56219.64109	581.0	I	0.00073	-0.00006
55513.91917	257.0	I	0.00080	0.00003	56220.73113	581.5	II	0.00169	0.00091
55515.00805	257.5	II	0.00060	-0.00017	56221.81938	582.0	I	0.00086	0.00007
55516.09758	258.0	I	0.00106	0.00029	56222.90953	582.5	II	0.00194	0.00115
55517.18634	258.5	II	0.00074	-0.00004	56223.99735	583.0	I	0.00068	-0.00011
55518.27576	259.0	I	0.00108	0.00030	56225.08749	583.5	II	0.00175	0.00096
55519.36441	259.5	II	0.00066	-0.00012	56226.17567	584.0	I	0.00084	0.00005
55520.45386	260.0	I	0.00102	0.00025	56227.26570	584.5	II	0.00180	0.00101
55521.54259	260.5	II	0.00068	-0.00009	56228.35365	585.0	I	0.00067	-0.00012
55522.63202	261.0	I	0.00104	0.00026	56229.44406	585.5	II	0.00200	0.00122
55524.81008	262.0	I	0.00094	0.00016	56230.53187	586.0	I	0.00073	-0.00006
55525.89886	262.5	II	0.00064	-0.00013	56231.62219	586.5	II	0.00198	0.00120
55526.98821	263.0	I	0.00091	0.00014	56232.71007	587.0	I	0.00079	0.00000
55528.07694	263.5	II	0.00057	-0.00021	56233.80040	587.5	II	0.00203	0.00124
55529.16618	264.0	I	0.00074	-0.00004	56234.88819	588.0	I	0.00075	-0.00004
55530.25517	264.5	II	0.00065	-0.00013	56235.97836	588.5	II	0.00184	0.00105

Table 4: Continued From Previous Page.

HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)	HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)
55531.34426	265.0	I	0.00066	-0.00011	56237.06635	589.0	I	0.00075	-0.00004
55532.43367	265.5	II	0.00099	0.00021	56239.24456	590.0	I	0.00081	0.00002
55533.52250	266.0	I	0.00075	-0.00003	56240.33416	590.5	II	0.00133	0.00054
55534.61189	266.5	II	0.00105	0.00028	56241.42267	591.0	I	0.00077	-0.00002
55535.70051	267.0	I	0.00060	-0.00017	56242.51185	591.5	II	0.00087	0.00008
55536.79010	267.5	II	0.00111	0.00033	56243.60086	592.0	I	0.00080	0.00001
55537.87868	268.0	I	0.00061	-0.00016	56244.69066	592.5	II	0.00152	0.00074
55538.96820	268.5	II	0.00105	0.00028	56245.77906	593.0	I	0.00085	0.00006
55540.05691	269.0	I	0.00069	-0.00009	56252.31346	596.0	I	0.00078	-0.00001
55541.14646	269.5	II	0.00116	0.00039	56253.40336	596.5	II	0.00161	0.00082
55542.23516	270.0	I	0.00079	0.00002	56254.49177	597.0	I	0.00094	0.00015
55543.32464	270.5	II	0.00119	0.00041	56255.58137	597.5	II	0.00147	0.00068
55545.50269	271.5	II	0.00108	0.00031	56256.66998	598.0	I	0.00100	0.00021
55546.59151	272.0	I	0.00082	0.00005	56257.75957	598.5	II	0.00151	0.00072
55547.68109	272.5	II	0.00133	0.00056	56258.84814	599.0	I	0.00100	0.00021
55548.76952	273.0	I	0.00069	-0.00009	56259.93743	599.5	II	0.00122	0.00043
55549.85912	273.5	II	0.00121	0.00043	56261.02635	600.0	I	0.00106	0.00027
55550.94780	274.0	I	0.00080	0.00003	56262.11576	600.5	II	0.00139	0.00060
55552.03744	274.5	II	0.00137	0.00060	56263.20444	601.0	I	0.00099	0.00020
55568.37258	282.0	I	0.00035	-0.00043	56264.29344	601.5	II	0.00091	0.00013
55569.46246	282.5	II	0.00115	0.00038	56265.38255	602.0	I	0.00095	0.00016
55570.55098	283.0	I	0.00060	-0.00017	56266.47120	602.5	II	0.00052	-0.00027
55571.64050	283.5	II	0.00104	0.00027	56267.56037	603.0	I	0.00061	-0.00018
55572.72924	284.0	I	0.00070	-0.00007	56269.73890	604.0	I	0.00099	0.00020
55573.81852	284.5	II	0.00091	0.00014	56270.82777	604.5	II	0.00079	0.00000
55574.90753	285.0	I	0.00084	0.00007	56271.91699	605.0	I	0.00092	0.00013
55575.99651	285.5	II	0.00075	-0.00003	56273.00502	605.5	II	-0.00012	-0.00091
55577.08546	286.0	I	0.00062	-0.00016	56274.09503	606.0	I	0.00081	0.00002
55578.17461	286.5	II	0.00069	-0.00009	56275.18293	606.5	II	-0.00037	-0.00116
55579.26374	287.0	I	0.00075	-0.00003	56276.27301	607.0	I	0.00064	-0.00016
55580.35269	287.5	II	0.00061	-0.00016	56277.36075	607.5	II	-0.00070	-0.00120
55581.44198	288.0	I	0.00083	0.00005	56278.45114	608.0	I	0.00062	-0.00017
55582.53087	288.5	II	0.00064	-0.00013	56279.53911	608.5	II	-0.00050	-0.00119
55583.62008	289.0	I	0.00078	0.00000	56280.62913	609.0	I	0.00045	-0.00034
55584.70916	289.5	II	0.00078	0.00000	56281.71735	609.5	II	-0.00041	-0.00110
55585.79818	290.0	I	0.00072	-0.00006	56282.80722	610.0	I	0.00039	-0.00040
55586.88733	290.5	II	0.00080	0.00002	56283.89567	610.5	II	-0.00025	-0.00104
55587.97639	291.0	I	0.00077	-0.00001	56284.98542	611.0	I	0.00043	-0.00036
55589.06548	291.5	II	0.00078	0.00001	56286.07420	611.5	II	0.00014	-0.00065
55590.15453	292.0	I	0.00076	-0.00002	56287.16371	612.0	I	0.00057	-0.00022
55591.24364	292.5	II	0.00079	0.00002	56288.25230	612.5	II	0.00008	-0.00071
55592.33269	293.0	I	0.00076	-0.00001	56289.34188	613.0	I	0.00059	-0.00020
55593.42162	293.5	II	0.00062	-0.00015	56290.43065	613.5	II	0.00027	-0.00052
55597.77804	295.5	II	0.00073	-0.00005	56291.52004	614.0	I	0.00059	-0.00020
55598.86729	296.0	I	0.00091	0.00013	56292.60883	614.5	II	0.00030	-0.00049
55599.95600	296.5	II	0.00053	-0.00025	56293.69826	615.0	I	0.00066	-0.00013
55601.04512	297.0	I	0.00058	-0.00019	56294.78707	615.5	II	0.00038	-0.00041
55602.13419	297.5	II	0.00057	-0.00020	56295.87649	616.0	I	0.00072	-0.00007
55603.22334	298.0	I	0.00065	-0.00013	56296.96556	616.5	II	0.00072	-0.00007
55604.31254	298.5	II	0.00077	-0.00001	56298.05474	617.0	I	0.00082	0.00003
55605.40170	299.0	I	0.00085	0.00008	56299.14364	617.5	II	0.00064	-0.00015
55606.49095	299.5	II	0.00103	0.00025	56300.23284	618.0	I	0.00077	-0.00003
55607.57990	300.0	I	0.00090	0.00012	56301.32203	618.5	II	0.00088	0.00009
55608.66880	300.5	II	0.00072	-0.00006	56302.41106	619.0	I	0.00083	0.00004
55609.75798	301.0	I	0.00082	0.00004	56303.50006	619.5	II	0.00075	-0.00004
55610.84706	301.5	II	0.00082	0.00005	56305.67817	620.5	II	0.00071	-0.00008
55611.93610	302.0	I	0.00079	0.00001	56306.76724	621.0	I	0.00071	-0.00008
55613.02544	302.5	II	0.00105	0.00028	56307.85628	621.5	II	0.00067	-0.00012
55614.11450	303.0	I	0.00103	0.00025	56308.94545	622.0	I	0.00076	-0.00003

Table 4: Continued From Previous Page.

HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)	HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)
55615.20329	303.5	II	0.00075	-0.00003	56310.03424	622.5	II	0.00048	-0.00031
55616.29270	304.0	I	0.00108	0.00031	56322.01451	628.0	I	0.00089	0.00010
55617.38160	304.5	II	0.00090	0.00013	56323.10328	628.5	II	0.00059	-0.00020
55618.47086	305.0	I	0.00109	0.00031	56324.19265	629.0	I	0.00088	0.00009
55619.55956	305.5	II	0.00071	-0.00006	56325.28146	629.5	II	0.00062	-0.00017
55620.64880	306.0	I	0.00087	0.00010	56326.37083	630.0	I	0.00091	0.00012
55621.73779	306.5	II	0.00078	0.00001	56327.45948	630.5	II	0.00048	-0.00031
55622.82702	307.0	I	0.00093	0.00016	56328.54903	631.0	I	0.00096	0.00017
55623.91617	307.5	II	0.00100	0.00023	56329.63763	631.5	II	0.00048	-0.00031
55625.00496	308.0	I	0.00072	-0.00006	56330.72720	632.0	I	0.00097	0.00018
55626.09425	308.5	II	0.00093	0.00016	56331.81633	632.5	II	0.00102	0.00023
55627.18316	309.0	I	0.00077	-0.00001	56332.90532	633.0	I	0.00093	0.00014
55628.27267	309.5	II	0.00120	0.00043	56333.99389	633.5	II	0.00043	-0.00036
55629.36126	310.0	I	0.00071	-0.00007	56335.08329	634.0	I	0.00075	-0.00004
55630.45087	310.5	II	0.00125	0.00047	56336.17220	634.5	II	0.00058	-0.00021
55631.53952	311.0	I	0.00082	0.00004	56337.26140	635.0	I	0.00071	-0.00008
55632.62923	311.5	II	0.00145	0.00067	56338.35037	635.5	II	0.00059	-0.00020
55633.71768	312.0	I	0.00082	0.00004	56339.43967	636.0	I	0.00083	0.00004
55634.80743	312.5	II	0.00150	0.00072	56340.52819	636.5	II	0.00026	-0.00053
56015.98447	487.5	II	0.00154	0.00075	56341.61783	637.0	I	0.00083	0.00003
56017.07249	488.0	I	0.00048	-0.00031	56342.70668	637.5	II	0.00060	-0.00019
56018.16265	488.5	II	0.00156	0.00078	56343.79597	638.0	I	0.00081	0.00002
56019.25054	489.0	I	0.00037	-0.00042	56344.88476	638.5	II	0.00053	-0.00026
56020.34079	489.5	II	0.00155	0.00076	56345.97409	639.0	I	0.00078	-0.00001
56021.42873	490.0	I	0.00041	-0.00038	56347.06295	639.5	II	0.00056	-0.00023
56022.51873	490.5	II	0.00133	0.00054	56348.15228	640.0	I	0.00081	0.00002
56023.60686	491.0	I	0.00039	-0.00040	56349.24112	640.5	II	0.00058	-0.00021
56024.69676	491.5	II	0.00121	0.00042	56350.33040	641.0	I	0.00078	-0.00001
56025.78520	492.0	I	0.00057	-0.00021	56351.41928	641.5	II	0.00059	-0.00020
56026.87496	492.5	II	0.00125	0.00047	56352.50856	642.0	I	0.00078	-0.00001
56027.96337	493.0	I	0.00059	-0.00020	56353.59744	642.5	II	0.00059	-0.00020
56029.05319	493.5	II	0.00133	0.00054	56354.68667	643.0	I	0.00074	-0.00005
56030.14102	494.0	I	0.00009	-0.00070	56355.77550	643.5	II	0.00050	-0.00029
56031.23087	494.5	II	0.00086	0.00008	56356.86478	644.0	I	0.00070	-0.00009
56032.31969	495.0	I	0.00060	-0.00018	56357.95469	644.5	II	0.00153	0.00074
56033.40903	495.5	II	0.00086	0.00008	56360.13205	645.0	II	0.00073	-0.00006
56034.49794	496.0	I	0.00070	-0.00009	56361.22130	646.0	I	0.00091	0.00012
56035.58742	496.5	II	0.00109	0.00031	56362.31014	646.5	II	0.00067	-0.00012
56036.67622	497.0	I	0.00082	0.00003	56363.39936	647.0	I	0.00081	0.00002
56037.76534	497.5	II	0.00086	0.00007	56364.48817	647.5	II	0.00054	-0.00025
56038.85417	498.0	I	0.00061	-0.00017	56365.57750	648.0	I	0.00080	0.00001
56039.94305	498.5	II	0.00042	-0.00036	56366.66574	648.5	II	-0.00004	-0.00083
56041.03229	499.0	I	0.00059	-0.00020	56367.75564	649.0	I	0.00078	-0.00001
56042.12093	499.5	II	0.00015	-0.00064	56368.84430	649.5	II	0.00037	-0.00042
56043.21049	500.0	I	0.00062	-0.00016	56369.93355	650.0	I	0.00054	-0.00025
56044.29886	500.5	II	-0.00008	-0.00087	56371.02246	650.5	II	0.00037	-0.00042
56045.38871	501.0	I	0.00069	-0.00010	56372.11170	651.0	I	0.00054	-0.00025
56046.47672	501.5	II	-0.00037	-0.00116	56373.20062	651.5	II	0.00038	-0.00041
56047.56681	502.0	I	0.00064	-0.00015	56374.28988	652.0	I	0.00056	-0.00023
56049.74523	503.0	I	0.00091	0.00012	56375.37862	652.5	II	0.00023	-0.00057
56050.83298	503.5	II	-0.00043	-0.00121	56376.46819	653.0	I	0.00072	-0.00007
56051.92335	504.0	I	0.00087	0.00009	56377.55672	653.5	II	0.00017	-0.00062
56053.01137	504.5	II	-0.00019	-0.00097	56378.64621	654.0	I	0.00059	-0.00020
56054.10148	505.0	I	0.00085	0.00007	56379.73515	654.5	II	0.00045	-0.00034
56055.18956	505.5	II	-0.00015	-0.00093	56380.82434	655.0	I	0.00056	-0.00023
56056.27967	506.0	I	0.00088	0.00009	56381.91349	655.5	II	0.00064	-0.00015
56057.36770	506.5	II	-0.00016	-0.00095	56383.00270	656.0	I	0.00077	-0.00003
56058.45765	507.0	I	0.00071	-0.00008	56384.09159	656.5	II	0.00058	-0.00021
56059.54582	507.5	II	-0.00020	-0.00099	56385.18087	657.0	I	0.00078	-0.00001

Table 4: Continued From Previous Page.

HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)	HJD (+24 00000)	E	Type	$(O - C)_I$ (day)	$(O - C)_{II}$ (day)
56060.63579	508.0	I	0.00069	-0.00010	56386.26983	657.5	II	0.00066	-0.00013
56061.72437	508.5	II	0.00019	-0.00059	56387.35907	658.0	I	0.00083	0.00004
56062.81401	509.0	I	0.00076	-0.00003	56388.44804	658.5	II	0.00072	-0.00008
56063.90283	509.5	II	0.00051	-0.00028	56389.53718	659.0	I	0.00079	0.00000
56064.99222	510.0	I	0.00081	0.00003	56390.62631	659.5	II	0.00083	0.00004
56066.08044	510.5	II	-0.00005	-0.00083	56392.80413	660.5	II	0.00050	-0.00030
56067.17033	511.0	I	0.00077	-0.00001	56393.89442	661.0	I	0.00172	0.00093
56068.25925	511.5	II	0.00061	-0.00018	56394.98219	661.5	II	0.00041	-0.00039
56069.34848	512.0	I	0.00076	-0.00002	56396.07162	662.0	I	0.00076	-0.00004
56070.43665	512.5	II	-0.00014	-0.00093	56397.16031	662.5	II	0.00038	-0.00042
56071.52670	513.0	I	0.00083	0.00004	56398.24970	663.0	I	0.00068	-0.00011
56072.61481	513.5	II	-0.00014	-0.00092	56399.33838	663.5	II	0.00029	-0.00050
56073.70483	514.0	I	0.00081	0.00003	56400.42779	664.0	I	0.00062	-0.00017
56074.79297	514.5	II	-0.00013	-0.00091	56401.51685	664.5	II	0.00060	-0.00019
56075.88343	515.0	I	0.00125	0.00046	56402.60595	665.0	I	0.00063	-0.00016
56076.97117	515.5	II	-0.00009	-0.00087	56403.69546	665.5	II	0.00106	0.00027
56079.14959	516.5	II	0.00018	-0.00060	56404.78419	666.0	I	0.00071	-0.00008
56080.23959	517.0	I	0.00110	0.00031	56405.87320	666.5	II	0.00064	-0.00015
56081.32776	517.5	II	0.00020	-0.00059	56406.96229	667.0	I	0.00066	-0.00013
56082.41775	518.0	I	0.00111	0.00033	56408.05140	667.5	II	0.00069	-0.00010
56083.50607	518.5	II	0.00035	-0.00044	56409.14039	668.0	I	0.00060	-0.00019
56084.59548	519.0	I	0.00069	-0.00010	56410.22963	668.5	II	0.00077	-0.00002
56085.68406	519.5	II	0.00019	-0.00060	56411.31848	669.0	I	0.00054	-0.00025
56086.77364	520.0	I	0.00069	-0.00009	56412.40803	669.5	II	0.00101	0.00022
56087.86219	520.5	II	0.00017	-0.00062	56413.49669	670.0	I	0.00059	-0.00020
56088.95208	521.0	I	0.00098	0.00019	56414.58625	670.5	II	0.00108	0.00029
56090.03947	521.5	II	-0.00071	-0.00120	56420.03127	673.0	I	0.00071	-0.00008
56091.13008	522.0	I	0.00082	0.00004	56421.12111	673.5	II	0.00148	0.00069
56092.21848	522.5	II	0.00015	-0.00064	56422.20938	674.0	I	0.00067	-0.00012
56093.30813	523.0	I	0.00072	-0.00007	56423.29955	674.5	II	0.00176	0.00097